CHANGE

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

8260.3B CHG 19

5/15/02

ARMY .... TM 95-226
NAVY .... OPNAV INST 3722.16C
USAF .... AFMAN 11-226(1)
USCG .... CG 318

SUBJ: UNITED STATES STANDARD FOR TERMINAL INSTRUMENT PROCEDURES (TERPS)

1. PURPOSE. Change 19 divides Order 8260.3B into five volumes to aid in the efficiency of its use. The conversion from one volume in revision B to five volumes will be completed in four steps consisting of Changes 19 through 22. Change 22 will complete the conversion process, and the document will then be identified as revision "C." Cross referencing between volumes will be minimal. This change also transmits new and revised sections of this order (Volume 1).

2. DISTRIBUTION: This change is distributed in Washington Headquarters to the branch level in the Offices of Airport Safety and Standards; and Communications, Navigation, and Surveillance Systems; to Flight Standards, Air Traffic, and Airway Facilities Services; to the National Flight Procedures Office and the Regulatory Standards Division at the Mike Monroney Aeronautical Center; to the branch level in the regional Flight Standards, Airway Facilities, Air Traffic, and Airports Divisions; special mailing list ZVS-827, and to special Military and Public Addressees.

3. CANCELLATION. With the publication of Change 19, the following orders will be canceled: Orders 8260.36A, Civil Utilization of Microwave Landing System (MLS), dated January 19, 1996; 8260.39A, Close Parallel ILS/MLS Approaches, dated December 29, 1999; 8260.41, Obstacle Assessment Surface Evaluation for Independent Simultaneous Parallel Precision Operations, dated September 15, 1995; and 8260.47, Barometric Vertical Navigation (VNAV) Instrument Procedures Development, dated May 26, 1998.

4. EFFECTIVE DATE: June 14, 2002

5. EXPLANATION OF CHANGES. This is the first change to Order 8260.3B that contains volumes. The volume and paragraph numbers are identified on the inside bottom corner of the page and chapter and page numbers (example 1-1) are on the outside bottom corner of the page. Significant areas of new direction, guidance, and policy included in this change are as follows:

a. VOLUME 1, General Criteria (current TERPS order). Installs the current TERPS Manual as Volume 1 (insert all changes to this portion of the order before adding the other volumes). This volume contains information and criteria applicable to any instrument approach procedure; e.g. administrative, en route, initial, intermediate, terminal fixes, holding, etc. Volume 1 will be completed with the implementation of Change 21.

(1) Chapter 1.

(a) **Paragraph 6a.** Adds the word "must" to convey that application of the criteria is mandatory.

(b) **Paragraph 122a.** Includes appendix number to the reference.

(c) **Paragraph 161a.** Clarifies directions for adding the suffix "DME" and noting the chart accordingly.

(d) **Paragraph 173.** Adds guidance for TERPS mathematics.

(e) **Paragragh 174.** Includes information for providing directive feedback.

(2) Chapter 2.

(a) **Paragraphs 201, 202, and 203.** Adds information and drawings concerning the TERPS concept of primary required obstacle clearance (ROC) and sloping and level obstacle clearance surfaces (OCS).

(b) **Paragraph 234e(1).** Provides guidance for establishing the minimum published holding altitude.

(c) **Table 3 in Paragraph 242b(2).** Changes minimum intermediate course lengths.

(d) **Paragraph 251a(2)(b).** Corrects information in this paragraph.

(e) **Paragraph 253.** Changes application of the visual descent point (VDP).

(f) **Paragraph 274d.** Brings up to date figures 17 and 18.

(g) **Paragraph 275.** Adds requirement for construction of turning or combination straight and turning missed approach areas. Adds note for clarification.

(h) **Paragraph 287b(4)(b).** Deletes example and figure 30 which is no longer required.

(i) **Paragraph 287c(2).** Changes figure 31-2 to reflect the current fix displacement calculations.

(3) Chapter 3.

(a) **Paragraph 324.** Adds current guidance concerning decision altitude (DA).

(b) **Paragraph 325.** Explains decision height (DH) as it relates to DA.

(c) **Paragraph 350.** Changes the title of table 9. TERPS Volume 3 now contains information for PRECISION minimums.

(4) **Chapter 8, paragraph 813c(1).** Updates reference to paragraph 523b(3) as all charts and explanations for solving secondary area obstacle problems have been deleted from appendix 2.

(5) **Chapter 9.** This change deletes chapter 9 with the exception of section 5 which becomes chapter 9, Localizer and Localizer Type Directional Aids (LDA). Paragraphs 951 through 957 become paragraphs 900 through 907. Volume 3 replaces most of chapter 9.

(6) **Chapter 10.** Volume 3 provides guidance that supersedes information in sections 2 and 3 of this chapter.

(7) **Chapter 11, Paragraph 1105.** Clarifies procedure identification of helicopter-only procedures.

(8) **Chapter 12.** This chapter becomes Volume 4 with four chapters; therefore, chapter 12 in this volume is reserved.

(9) **Chapter 15.**

(a) **Paragraph 1513d(2).** Updates reference to 1413d(1) as the ROC applied for this circling approach should be the same as the criteria applied to other chapters.

(b) **Paragraph 1513f.** Updates reference to chapter 2, section 8 as section 2 no longer contains criteria for the use of radio fixes.

(10) **Chapter 17, paragraph 1731b.** Updates reference to paragraph 1721 as all charts and explanations for solving secondary area obstacle problems have been deleted from appendix 2.

(11) **Appendix 1.** Adds title to appendix and an alphabetical listing of all the acronyms and abbreviations for old and new aviation terms used frequently throughout this order.

(12) **Appendix 2.** Deletes appendix 2 as this information is now in Volume 3, appendix 5.

(13) **This change also provides guidance** that supersedes chapter 3, section 1 of Order 8260.48, Area Navigation (RNAV) Approach Construction Criteria, dated April 8, 1999. The direction and guidance published in this change supersedes RELATED information in Order 8260.48. A major portion of Order 8260.48 remains in effect.

b. **VOLUME 2, Nonprecision Approach Procedure (NPA) Construction**, is reserved for Change 21. It will contain criteria central to nonprecision final approach segment construction. VHF omnidirectional range (VOR), VOR/distance measuring equipment (DME), nondirectional beacon (NDB), tactical air navigation (TACAN), airport surveillance radar (ASR), airborne radar approaches (ARA), localizer, simplified directional facility (SDF), localizer directional aid (LDA), direction finder (DF), area navigation (RNAV), and lateral navigation (LNAV) systems are supported. Criteria applicable to the initial missed approach climb unique to nonprecision approaches will be included in this volume.

c. VOLUME 3, Precision Approach (PA) and Barometric Vertical Navigation (Baro VNAV) Approach Procedure Construction. Replaces criteria originally located in chapter 9 and guidance from Orders 8260.36A, 8260.39A, 8260.41, and 8260.48, chapter 2, paragraphs 2.1, 2.3, 2.5-2.10, 2.12, and chapter 3, sections 1 and 2. This volume contains the final segment construction criteria for navigational systems that provide vertical guidance, instrument landing system (ILS), microwave landing system (MLS), transponder landing system (TLS), precision approach radar (PAR), Global Navigation Satellite landing system (GLS), wide area augmentation system (WAAS), local area augmentation system (LAAS), and Baro-VNAV. Obstruction clearance criteria applicable to simultaneous parallel, simultaneous converging, and Category II/III operations are included. Intermediate segment requirements and initial missed approach climb criteria unique to precision and Baro VNAV approaches are also contained in this volume.

d. VOLUME 4, Departure Procedure Construction. Replaces criteria originally located in chapter 12 of the TERPS order. This volume contains criteria departure obstruction supporting VOR, NDB, TACAN, ASR, localizer, and RNAV (in Change 21) navigation systems. Diverse departure, climb visually over the airport, and Air Traffic Control diverse vector areas are also covered. These criteria will be amended for use in the missed approach segment in Change 21.

e. VOLUME 5, Helicopter and Powered Lift Instrument Procedure Construction, is reserved for Change 21. It will contain all guidance for instrument procedure construction (en route, departure, approach) criteria.

6. PUBLICATION FORMAT. The double column, traditional paragraph numbering scheme of the TERPS document is changing to a single column, decimal number system more consistent with RTCA and the International Civil Aviation Organization (ICAO). The print is clear and illustrations are larger.

7. DISPOSITION OF TRANSMITTAL. The transmittal must be RETAINED AND FILED IN THE BACK OF THIS MANUAL until it is superseded by a revised order.

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VOLUME 4. DEPARTURE PROCEDURE CONSTRUCTION

VOLUME 5. HELICOPTER AND POWER LIFT INSTRUMENT PROCEDURE CONSTRUCTION

RESERVED

FAA ORDER **8260.3B**

Army
Navy
Coast Guard
Air Force

TM 95-226
OPNAV Inst. 3722.16C
CG 318
AFMAN 11-226(I)

UNITED STATES STANDARD
FOR
TERMINAL
INSTRUMENT
PROCEDURES
(TERPS)

VOLUME 1

GENERAL CRITERIA

U. S. DEPARTMENT OF TRANSPORTATION

FEDERAL AVIATION ADMINISTRATION

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GENERAL CRITERIA

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CHAPTER 1. ADMINISTRATIVE

SECTION 1. SCOPE

1. PURPOSE. This order contains criteria that shall be used to formulate, review, approve, and publish procedures for instrument approach and departure of aircraft to and from civil and military airports. These criteria are for application at any location over which an appropriate United States agency exercises jurisdiction.

2. DISTRIBUTION. This order is distributed to selected Federal Aviation Administration (FAA) addressees. For distribution within the Department of Defense, see pages v and vi.

3. CANCELLATION. Order 8260.34, Glide Slope Threshold Crossing Height Requirements, dated 10/26/83, is canceled. This change also incorporates criteria contained in VN Supplements 2 and 3 to Order 8260.3B; therefore, VN SUP 2, dated 10/8/92, and VN SUP 3, dated 1/11/93, are canceled.

4. EXISTING PROCEDURES. Existing procedures shall comply with these standards. Approval of nonstandard procedures as required is specified in paragraph 141.

5. TYPES OF PROCEDURES. Criteria are provided for the following types of authorized instrument procedures:

a. Precision Approach (PA).

(1) Straight-In. A descent in an approved procedure where the navigation facility alignment is normally on the runway centerline, and glide slope (GS) information is provided. For example, Precision Approach Radar (PAR), Instrument Lnding System (ILS), and Microwave Landing System (MLS) procedures are precision approaches.

(2) Simultaneous. A procedure that provides for approaches to parallel runways. This procedure uses two or more ILS-equipped parallel runways. Simultaneous approaches, when authorized, shall be radar monitored. Military commanders may approve simultaneous approaches based upon dual precision radar.

b. Nonprecision Approach (NPA).

(1) Straight-In. A descent in an approved procedure in which the final approach course (FAC) alignment and descent gradient permits authorization of straight-in landing minimums.

c. Departure Procedures. Procedures designed to provide obstacle clearance during instrument departures.

6. WORD MEANINGS. Word meanings as used in this manual:

a. Shall or Must means that application of the criteria is mandatory.

b. Should means that application of the criteria is recommended.

c. May means that application of the criteria is optional.

7.-119. RESERVED.

SECTION 2. ELIGIBILITY, APPROVAL, AND RETENTION

120. ELIGIBILITY.

a. Military Airports. Procedures at military airports shall be established as required by the directives of the appropriate military service.

b. Civil Airports. Instrument procedures shall be provided at civil airports open to the aviation public whenever a reasonable need is shown. No minimum number of potential instrument approaches is specified; however, the responsible FAA office must determine that a public procedure will be beneficial to more than a single user or interest. Private procedures, for the exclusive use of a single interest, may be provided on a reimbursable basis under Title 14 of the Code of Federal Regulations (14 CFR) Part 171, where applicable, if they do not unduly conflict with the public use of airspace. Reasonable need is deemed to exist when the instrument flight procedure will be used by:

(1) A certificated air carrier, air taxi, or commercial operator; or

(2) Two or more aircraft operators whose activities are directly related to the commerce of the community; or

(3) Military aircraft.

121. REQUESTS FOR PROCEDURES. Requests for military procedures are processed as described by the appropriate military service. No special form is required for requesting civil procedures. Civil requests may be made by letter to the appropriate Regional Office. Requests for civil procedures shall be accepted from any aviation source, provided the request shows that the airport owner/operator has been advised of this request. (This advice is necessary only when the request is for an original procedure to an airport not already served by an approach procedure.) The FAA will advise airport owners/operators of additional requests for procedures as soon as possible after receipt thereof.

122. APPROVAL. Where a military requirement or reasonable civil need has been established, a request for an instrument approach procedure (IAP) and/or instrument departure procedure for an airport shall be approved if the following minimum standards are met:

a. Airport. The airport landing surfaces must be adequate to accommodate the aircraft that can be reasonably expected to use the procedure. Appropriate runway markings, hold position markings, and signs, required by AC 150/5340-1, Marking of Paved Areas on Airports, shall be established and in place; and all runway design standards in appendix 16 of AC 150/5300-13, Airport Design, must be met. Runway lighting is required for approval of night instrument operations. EXCEPTION: Do NOT deny takeoff and departure procedures at night due solely to the absence of runway edge lights. The airport must have been found acceptable for instrument flight rules (IFR) operations as a result of an airport airspace analysis conducted pursuant to Order 7400.2, Procedures for Handling Airspace Matters, and/or appropriate military directives, as applicable. Only circling minimums shall be approved to airports where the runways are not clearly defined.

b. Navigation Facility. All instrument and visual navigation facilities used must successfully pass flight inspection.

c. Obstacle Marking and Lighting. Obstacles which penetrate 14 CFR Part 77 imaginary surfaces are obstructions and, therefore, should be marked and lighted, insofar as is reasonably possible under FAA Advisory Circular AC 70/7460.1, Obstruction Marking and Lighting. Those penetrating the 14 CFR Part 77 approach and transitional surfaces should be removed or made conspicuous under that AC. Normally, objects which are shielded need not be removed or made conspicuous.

NOTE: *In military procedures, the appropriate military directives apply.*

d. Weather Information. Terminal weather observation and reporting facilities must be available for the airport to serve as an alternate airport. Destination minimums may be approved when a general area weather report is available prior to commencing the approach and approved altimeter settings are available to the pilot prior to and during the approach consistent with communications capability.

e. Communications. Air-to-ground communications must be available at the initial approach fix (IAF) minimum altitude and when the aircraft executing the missed approach reaches the missed approach altitude. At lower altitudes, communications shall be required where essential for the safe and efficient use of airspace. Air-to-ground communication normally consists of ultra high frequency (UHF) or very high frequency (VHF) radio, but high frequency (HF) communication may be approved at locations which have a special need and capability. Other suitable means of point-to-point communication, such as commercial telephone, are also required to file and close flight plans.

123. RETENTION AND CANCELLATION. Civil instrument procedures shall be canceled when a re-evaluation of the usefulness of an IAP indicates that the benefits derived are not commensurate with the costs of retaining the procedure. This determination will be based upon an individual evaluation of requirements peculiar to each specific location, and will consider airport complexity, military requirements, planned airport expansion, and the need for a backup or supplement to the primary instrument approach system. Certain special procedures exist, generally based on privately operated navigation facilities. When a procedure based on a public facility is published, special procedures for that airport shall be canceled unless retention provides an operational advantage to the user. Before an instrument procedure is canceled, coordination with civil and military users shall be effected. Care shall be taken not to cancel procedures required by the military or required by air carrier operators at provisional or alternate airports. Military procedures shall be retained or canceled as required by the appropriate military authority.

124.-129. RESERVED.

SECTION 3. RESPONSIBILITY AND JURISDICTION

130. RESPONSIBILITY.

a. Military Airports. The United States Army, Navy, Air Force, and Coast Guard, shall establish and approve instrument procedures for airports under their respective jurisdictions. The FAA will accept responsibility for the development and/or publication of military procedures when requested to do so by the appropriate military service through an interagency agreement. Military instrument procedures are official procedures. The FAA (AVN-100 Regional FPO) shall be informed when military procedures are canceled.

b. Civil Airports. The FAA shall establish and approve instrument procedures for civil airports.

c. Military Procedures at Civil Airports. Where existing FAA approach or departure procedures at civil airports do not suffice, the military shall request the FAA to develop procedures to meet military requirements. Modification of an existing FAA procedure or development of a new procedure may meet these requirements. The FAA shall formulate, coordinate with the military and industry, and publish and maintain such procedures. The military shall inform the FAA when such procedures are no longer required.

131. JURISDICTION. The United States Army, Navy, Air Force, Coast Guard, and Marine Corps Commanding Officers, or FAA Regional Directors having jurisdiction over airports are responsible for initiating action under these criteria to establish or revise TERPS when a reasonable need is identified, or where:

a. New facilities are installed.

b. Changes to existing facilities necessitate a change to an approved procedure.

c. Additional procedures are necessary.

d. New obstacles or operational uses require a revision to the existing procedure.

132.-139. RESERVED.

SECTION 4. ESTABLISHMENT

140. FORMULATION. Proposed procedures shall be prepared under the applicable portion of this publication as determined by the type and location of navigation facility and procedure to be used. To permit use by aircraft with limited navigational equipment, the complete procedure should be formulated on the basis of a single navigation facility whenever possible. However, the use of an additional facility of the same or different type in the procedure to gain an operational advantage is permitted.

141. NONSTANDARD PROCEDURES. The standards contained in this manual are based on reasonable assessment of the factors which contribute to errors in aircraft navigation and maneuvering. They are designed primarily to assure that safe flight operations for all users result from their application. The dimensions of the obstacle clearance areas are influenced by the need to provide for a smooth, simply computed progression to and from the en route system. Every effort shall be made to formulate procedures in accordance with these standards; however, peculiarities of terrain, navigation information, obstacles, or traffic congestion may require special consideration where justified by operational requirements. In such cases, nonstandard procedures that deviate from these criteria may be approved, provided they are fully documented and an equivalent level of safety exists. A nonstandard procedure is not a substandard procedure, but is one that has been approved after special study of the local problems has demonstrated that no derogation of safety is involved. The FAA, Flight Technologies and Procedures Division, AFS-400, is the approving authority for nonstandard civil procedures. Military procedures which deviate from standards because of operational necessity, and in which an equivalent level of safety is not achieved, shall include a cautionary note to identify the hazard and shall be marked "not for civil use."

142. CHANGES. Changes in instrument procedures shall be prepared and forwarded for approval in the same manner as in the case of new procedures. Changes so processed will not be made solely to include minor corrections necessitated by changes in facility frequencies, variation changes, etc., or by other minor changes not affecting the actual instrument procedure. Changes that require reprocessing are those that affect fix, course, altitude, or published minimums.

143.-149. RESERVED.

SECTION 5. COORDINATION

150. COORDINATION. It is necessary to coordinate instrument procedures to protect the rights of all users of airspace.

a. Military Airports. All instrument procedures established or revised by military activities for military airports shall be coordinated with the FAA or appropriate agency or an overseas host nation. When a procedure may conflict with other military or civil activities, the procedure shall also be coordinated with those activities.

b. Civil Airports. Prior to establishing or revising instrument procedures for civil airports, the FAA shall, as required, coordinate such procedures with the appropriate civil aviation organizations. Coordination with military activities is required when a military operating unit is based at the airport or when the proximity of a military airport may cause procedures conflicts.

c. Air Traffic Control (ATC). Prior to establishing or revising instrument procedures for a military or civil airport, the initiating office shall coordinate with the appropriate FAA Air Traffic office to ensure compatibility with air traffic flow and to assess the impact of the proposed procedure on current or future air traffic programs.

d. Airspace Actions. Where action to designate controlled airspace for a procedure is planned, the airspace action should be initiated sufficiently in advance so that effective dates of the procedure and the airspace action will coincide.

e. Notice to Airmen (NOTAM). A NOTAM to **RAISE** minimums may be issued in case of emergencies; i.e., facility outages, facility out-of-tolerance conditions, new construction that penetrates critical surfaces, etc. NOTAM's may also be issued to **LOWER** minimums when a supporting facility is added and a significant change in minimums (60 feet in MDA/DH or a reduction in visibility) will result. A NOTAM may be issued to **RAISE OR LOWER** minimums as appropriate on a no-FAF procedure when a procedure turn (PT) altitude is modified as the result of construction or terrain, or when a facility restriction is removed. However, a complete new procedure may not be issued by NOTAM, except where military requirements dictate. ATC shall be advised of the required NOTAM action prior to issuance and normal coordination shall be effected as soon as practical.

151. COORDINATION CONFLICTS. In areas under the FAA jurisdiction, coordination conflicts that cannot be resolved at the field level shall be submitted to the appropriate FAA region for additional coordination and resolution. Problems that are unresolved at the regional level shall be forwarded to the FAA, AFS-400, for action. If the problem involves a military procedure, parallel action through military channels shall be taken to expedite coordination at the appropriate level.

152.-159. RESERVED.

SECTION 6. IDENTIFICATION OF PROCEDURES

160. IDENTIFICATION OF PROCEDURES. Instrument procedures shall be identified to be meaningful to the pilot, and to permit ready identification in ATC phraseology.

161. STRAIGHT-IN PROCEDURE IDENTIFICATION. Instrument procedures that meet criteria for authorization of straight-in landing minima shall be identified by a prefix describing the navigational system providing the final approach guidance and the runway to which the final approach course is aligned:

a. Non-RNAV. ILS runway (RWY) 18R, localizer (LOC) back course (BC) RWY 7, tactical air navigational aid (TACAN) RWY 36, localizer type directional aid (LDA) RWY 4, nondirectional radio beacon (NDB) RWY 21, VHF omnidirectional radio range (VOR) RWY 15, VOR/distance measuring equipment (DME) RWY 6, ILS or TACAN RWY 9, etc. A slash (/) indicates more than one type of equipment is required to execute the final approach; e.g., VOR/DME, etc. ILS procedures do not require DME to fly the final approach, even if a DME fix has been substituted for one of the marker beacons, therefore, ILS procedures shall not be named ILS/DME. If a procedure requires DME to fly the final approach, the suffix "DME" shall be added; e.g., LOC/DME RWY (number). A chart shall be noted to indicate RADAR is required for approach minima. When a LOC procedure is published on an ILS chart, it is a combined procedure. When procedures are combined, the word "or" shall indicate either type of equipment may be be used to execute the final approach; e.g., ILS or LOC/DME, ILS or TACAN, VOR/DME or TACAN, etc. Where more than one approach using the same final approach guidance is developed to the same runway, identify each for the runway/navigational aid combination with alphabetical suffix beginning at the end of the alphabet; e.g., ILS Z RWY 28L (first procedure), ILS Y RWY 28L (second procedure), ILS X RWY 28L (third procedure), etc.

b. RNAV. Identify WAAS, Baro VNAV, and GPS approach procedures as RNAV (sensor) RWY (Number); e.g., RNAV (GPS) RWY 21, RNAV (GPS, DME/DME) RWY 15.

NOTE: The published minima lines will identify required RNAV sensors; e.g., LPV, LNAV/VNAV (includes degraded WAAS and Baro VNAV), or LNAV (includes GPS and WAAS without glidepath). A single RNAV approach will be *published depicting LPV and/or LNAV/VNAV, and/or LNAV minimums where they share the same courses and altitudes.*

c. OTHER RNAV. Identify VOR/DME and LORAN based RNAV procedures as (system) RNAV RWY (number); e.g., VOR/DME RNAV RWY 13, LORAN RNAV RWY 31.

162. CIRCLING PROCEDURE IDENTIFICATION. When an approach procedure does not meet criteria for straight-in landing minimums authorization, it shall be identified by the type of navigational aid (NAVAID) which provides final approach guidance, and an alphabetical suffix starting with the beginning of the alphabet. The first procedure formulated shall bear the suffix "A" even though there may be no intention to formulate additional procedures. If additional procedures are formulated, they shall be identified alphabetically in sequence, e.g., VOR-A, VOR/ DME-B, NDB-C, NDB-D, LDA-E, RNAV-A, etc. A revised procedure will bear its original identification.

163. DIFFERENTIATION. Where high altitude procedures are required, the procedure identification shall be prefixed with the letters "HI" e.g., HI-VOR RWY 5.

164.-169. RESERVED.

SECTION 7. PUBLICATION

170. SUBMISSION. Instrument procedures shall be submitted by the approving authority on forms provided by the originating agency. A record of coordination shall be maintained by the originating agency. Procedures shall be routed under current orders or directives of the originating agency.

171. ISSUANCE. The following are designated as responsible offices for the release of approved instrument procedures for each agency.

a. Army. Director, U.S. Army Aeronautical Services Agency.

b. Navy and Marine Corps. Chief of Naval Operations (CNO), Naval Flight Information Group.

c. Air Force. Headquarters, Air Force Flight Standards Agency, Instrument Standards Division.

d. Coast Guard. Commandant, U.S. Coast Guard.

e. Civil. Administrator, FAA.

172. EFFECTIVE DATE. TERPS and revisions thereto shall be processed in sufficient time to permit publication and distribution in advance of the effective date. Effective dates should normally coincide with scheduled airspace changes except when safety or operational effectiveness is jeopardized. In case of emergency, or when operational effectiveness dictates, approved procedures may be disseminated by NOTAM (see paragraph 150e). Procedures disseminated by NOTAM must also be processed promptly in the normal fashion and published in appropriate instrument procedures charts and in the Federal Register when required.

173. MATHEMATICS CONVENTION.

a. Definition of Mathmatical Functions.

$a+b$ indicates addition

$a-b$ indicates subtraction

$a \times b$ indicates multiplication

$\frac{a}{b}$ indicates division

$(a \times b)$ indicates the result of the process within the parethesis

$|a-b|$ indicates absolute value {the result of the process between the vertical lines is assigned a positive sign}

$\approx$ indicates approximate equality

$\sqrt{a}$ indicates the square root of quantity "a"

a^2 indicates $a \times a$

$\tan(a)$ indicates the tangent of "a" degrees

$\tan^{-1}(a)$ indicates the arc tangent of "a"

$\sin(a)$ indicates the sine of "a" degrees

$\sin^{-1}(a)$ indicates the arc sine of "a"

$\cos(a)$ indicates the cosine of "a" degrees

$\cos^{-1}(a)$ indicates the arc cosine of "a"

b. Operational Precedence (Order of Operations).

First: **Grouping Symbols: parentheses, brackets, braces, fraction bars, etc.**
Second: **Functions: tangent, sine, cosine, arcsine and other defined functions**
Third: **Exponentiation: powers and roots**
Fourth: **Multiplication and Division: products and quotients**
Fifth: **Addition and Subtraction: sums and differences**

e.g.,

$5-3\times 2=-1$ because multiplication takes precedence over subtraction

$(5-3)\times 2=4$ because parentheses take precedence over multiplication

$\frac{6^2}{3}=12$ because exponentiation takes precedence over division

$\sqrt{9+16}=5$ because the square root sign is a grouping symbol

$\sqrt{9}+\sqrt{16}=7$ because roots take precedence over addition

$\frac{\sin(30^\circ)}{0.5}=1$ because functions take precedence over division

$\sin\left(\frac{30^\circ}{0.5}\right)=0.8660254$ because parentheses take precedence over functions

NOTES ON CALCULATOR USAGE:

1. *Most calculators are programmed with these rules of precedence.*
2. *When possible, let the calculator maintain all of the available digits of a number in memory rather than re-entering a rounded number. For highest accuracy from a calculator, any rounding that is necessary should be done at the latest opportunity.*

174. INFORMATION UPDATE. For your convenience, FAA Form 1320-19, Directive Feedback Information, is included at the end of this order to provide any comments on deficiencies found, clarifications needed, or suggested improvements regarding the contents to this order. When forwarding comments to the originating office for consideration, please provide a complete explanation of why the suggested change is necessary.

175.-199. RESERVED

CHAPTER 2. GENERAL CRITERIA

200. SCOPE. This chapter contains only that information common to all types of TERPS. Criteria, which do not have general application, are located in the individual chapters concerned with the specific types of facilities.

SECTION 1. COMMON INFORMATION

201. TERPS. Concept of Primary Required Obstacle Clearance (ROC). The title of this order, United States Standard for Terminal Instrument Procedures (TERPS), contains a key word in defining the order's content. The word is "STANDARD;" something set up and established by authority as a rule for the measure of quantity, weight, extent, value, or quality.

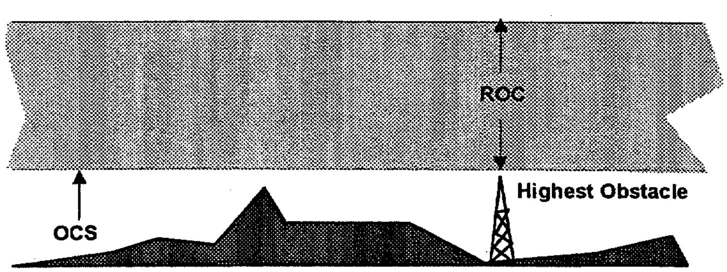
a. The TERPS document specifies the minimum measure of obstacle clearance that is considered by the FAA (the Federal authority) to supply a satisfactory level of vertical protection. The validity of the protection is dependent, in part, on assumed aircraft performance. In the case of TERPS, it is assumed that aircraft will perform within certification requirements.

b. The following is an excerpt from the foreword of this order: "These criteria are predicated on normal aircraft operations for considering obstacle clearance requirements." Normal aircraft operation means all aircraft systems are functioning normally, all required navigational aids (NAVAID's) are performing within flight inspection parameters, and the pilot is conducting instrument operations utilizing instrument procedures based on the TERPS standard to provide ROC. While the application of TERPS criteria indirectly addresses issues of flyability and efficient use of NAVAID's, the major safety contribution is the provision of obstacle clearance standards. This facet of TERPS allows aeronautical navigation in instrument meteorological conditions (IMC) without fear of collision with unseen obstacles. ROC is provided through application of level and sloping OCS.

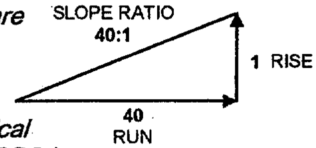
202. Level OCS. The level OCS concept is applicable to "level flight" segments. These segments are level flight operations intended for en route, initial, intermediate segments, and nonprecision final approaches. A single ROC value is applied over the length of the segment. These values were determined through testing and observation of aircraft and pilot performance in various flight conditions. Typical ROC values are: for en route procedure segments, 1,000 feet (2,000 over designated mountainous terrain); and for initial segments, 1,000 feet, 500 feet in intermediate segments, and 350/300/250 feet in final segments.

a. This method of applying ROC results in a horizontal band of airspace that cannot be penetrated by obstacles. Since obstacles always extend upward from the ground, the bottom surface of the ROC band is mathematically placed on top of the highest obstacle within the segment. The depth (ROC value) of the band is added to the obstacle height to determine the minimum altitude authorized for the segment. The bottom surface of the ROC band is referred to as the level OCS. Therefore, level flight segments are evaluated by the level OCS application standard (see figure 1-1).

Figure 1-1. Minimum Segment Altitude. Par 202a



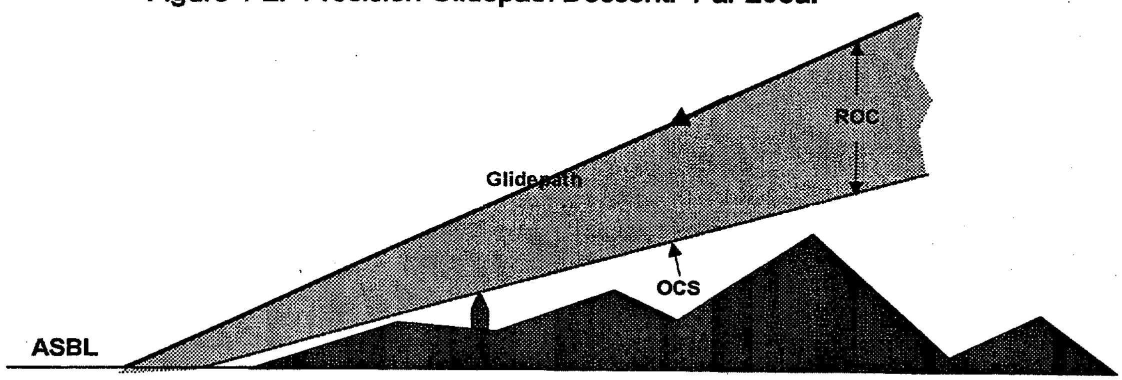
203. Sloping Obstacle Clearance Surfaces (OCS). The method of applying ROC, in segments dedicated to descending on a glidepath or climbing in a departure or missed approach segment, requires a different obstacle clearance concept than the level OCS because the ROC value must vary throughout the segment. The value of ROC near the runway is relatively small, and the value at the opposite end of the segment is sufficient to satisfy one of the level surface standards above. It follows then, that a sloping OCS is a more appropriate method of ROC application.



NOTE: Slope ratios are normally expressed in terms of rise over run in engineering and professional technical jargon. However, TERPS has traditionally expressed slope ratios in terms of run over rise; e.g., 34:1, 40:1.

a. Descending on a Precision Glidepath. The obstacle evaluation method for descent on a glidepath is the application of a descending OCS below the glidepath. The vertical distance between the glidepath and the OCS is ROC; i.e., ROC = (glidepath height) - (OCS height). The ROC decreases with distance from the final approach fix as the OCS and glidepath converge on the approach surface baseline (ASBL) height (see figure 1-2). The OCS slope and glidepath angle values are interdependent: OCS Slope = 102 ÷ glidepath angle; or glidepath angle = 102 ÷ OCS slope. This relationship is the standard that determines the ROC value since $ROC = (\text{glidepath height}) - (\text{OCS height})$.

Figure 1-2. Precision Glidepath Descent. Par 203a.



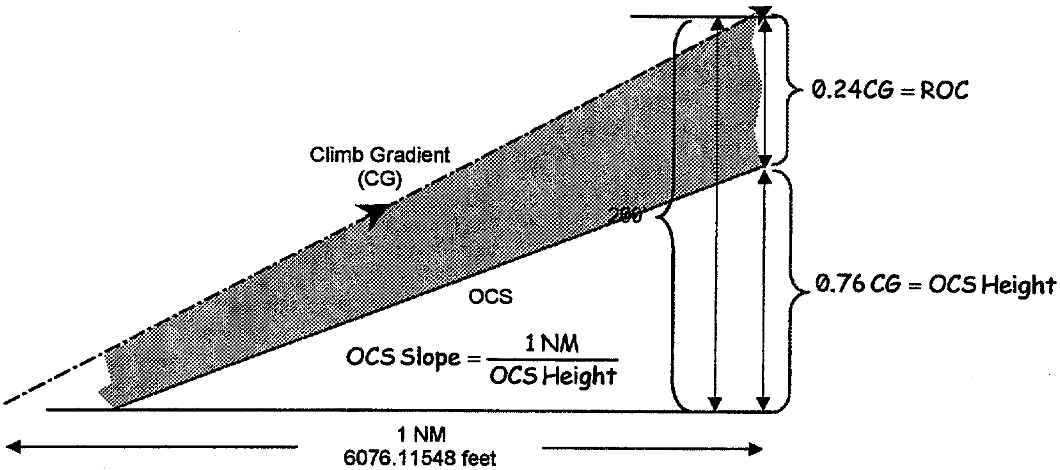
(1) **If the OCS is penetrated**, the OCS slope may be adjusted upward, thereby increasing the glidepath angle. The glidepath angle would increase because it is dependent on the required slope.

(2) **Descent on a glidepath** generated by systems that do not meet the system precision requirements of ICAO PANS-OPs, Annex 10, such as barometric vertical navigation (Baro-VNAV), provide ROC through application of a descending sloping surface based on standards using differing formulas, but the concept is the same.

b. Climbing on departure or missed approach. The concept of providing obstacle clearance in the climb segment, in instrument procedures, is based on the aircraft maintaining a minimum climb gradient. The climb gradient must be sufficient to increase obstacle clearance along the flightpath so that the minimum ROC for the subsequent segment is achieved prior to leaving the climb segment (see figure 1-3). For TERPS purposes, the MINIMUM climb gradient that will provide adequate ROC in the climb segment is 200 ft/NM.

(1) **The obstacle evaluation method** for a climb segment is the application of a rising OCS below the minimum climbing flightpath. Whether the climb is for departure or missed approach is immaterial. The vertical distance between the climbing flightpath and the OCS is ROC. ROC for a climbing segment is defined as $ROC = 0.24\,CG$. This concept is often called the 24% rule. Altitude gained is dependent on climb gradient (CG) expressed in feet per NM. The minimum ROC supplied by the 200 ft/NM CG is 48 ft/NM $(0.24 \times 200 = 48)$. Since 48 of the 200 feet gained in 1 NM is ROC, the OCS height at that point must be 152 feet $(200 - 48 = 152)$, or 76% of the CG $(152 \div 200 = 0.76)$. The slope of a surface that rises 152 over 1 NM is 40 (6076.11548 ÷ 152 = 39.97 = 40).

Figure 1-3. Climb Segment. Par 202b.



(2) **Where an obstruction penetrates the OCS,** a nonstandard climb gradient (greater than 200 ft/NM) is required to provide adequate ROC. Since the climb gradient will be greater than 200 ft/NM, ROC will be greater than 48 ft/NM $(0.24 \times CG > 200 = ROC > 48)$. The nonstandard ROC expressed in ft/NM can be calculated using the formula: $(0.24\,h) \div (0.76\,d)$ where "h" is the height of the obstacle above the altitude from which the climb is initiated, and "d" is the distance in NM from the initiation of climb to the obstacle. Normally, instead of calculating the nonstandard ROC value, the required climb gradient is calculated directly using the formula: $h \div (0.76d)$.

c. **In the case of an instrument departure,** the OCS is applied during the climb until at least the minimum en route value of ROC is attained. The OCS begins at the departure end of runway, at the elevation of the runway end. It is assumed aircraft will cross the departure end-of-runway at a height of at least 35 feet. However, for TERPS purposes, aircraft are assumed to lift off at the runway end (unless the procedures state otherwise). The ROC value is zero at the runway end, and increases along the departure route until the appropriate ROC value is attained to allow en route flight to commence.

d. **In the case of a missed approach procedure,** the climbing flightpath starts at the height of MDA or DA minus height loss. The OCS starts approximately at the MAP/DA point at an altitude of MDA/DA minus the final segment ROC and adjustments. Therefore, the final segment ROC is assured at the beginning of the OCS, and increases as the missed approach route progresses. The OCS is applied until at least the minimum initial or en route value of ROC is attained, as appropriate.

e. **Extraordinary circumstances, such as a mechanical or electrical malfunction,** may prevent an aircraft from achieving the 200 ft/NM minimum climb gradient assumed by TERPS. In these cases, adequate obstacle clearance may not be provided by published instrument procedures. Operational procedures contained outside TERPS guidelines are required to cope with these abnormal scenarios.

204.-209. RESERVED.

210. UNITS OF MEASUREMENT. Units of measurement shall be expressed as set forth below:

a. **Bearings, Courses, and Radials.** Bearings and courses shall be expressed in degrees magnetic. Radials shall also be expressed in degrees magnetic, and shall further be identified as radials by prefixing the letter "R" to the magnetic bearing FROM the facility. For example, R-027 or R-010.

b. **Altitudes.** The unit of measure for altitude in this publication is feet. Published heights below the transition level (18,000 feet) shall be expressed in feet above mean sea level (MSL); e.g. 17,900 feet. Published heights at and above the transition level (18,000 feet) shall be expressed as flight levels (FL); e.g., FL 180, FL 190, etc. Reference Title 14 of the Code of Federal Regulations (14 CFR) Part 91.81, and Order 7110.65, Air Traffic Control, paragraph 85.

c. Distances. Develop all distances in nautical miles (NM) (6076.11548 feet or 1852 meters per NM) and hundredths thereof, except where feet are required. Use the following formulas for feet and meter conversions:

$$\text{feet} = \frac{\text{meters}}{0.3048} \qquad \text{meters} = \text{feet} \times 0.3048$$

When applied to visibilities, distances shall be expressed in statute miles (SM) (5,280 feet per SM) and the appropriate fractions thereof. Expression of visibility values in NM is permitted in overseas areas where it coincides with the host nation practice. Runway visual range (RVR) must be expressed in feet.

d. Speeds. Aircraft speeds must be expressed in knots indicated airspeed (KIAS).

e. Determination of Correctness of Distance and Bearing Information. The approving agency is the authority for correctness of distance and bearing information, except that within the United States, its territories, and possessions, the National Oceanic and Atmospheric Administration is the authority for measurements between all civil navigation aids and between those facilities incorporated as part of the National Airspace System (NAS).

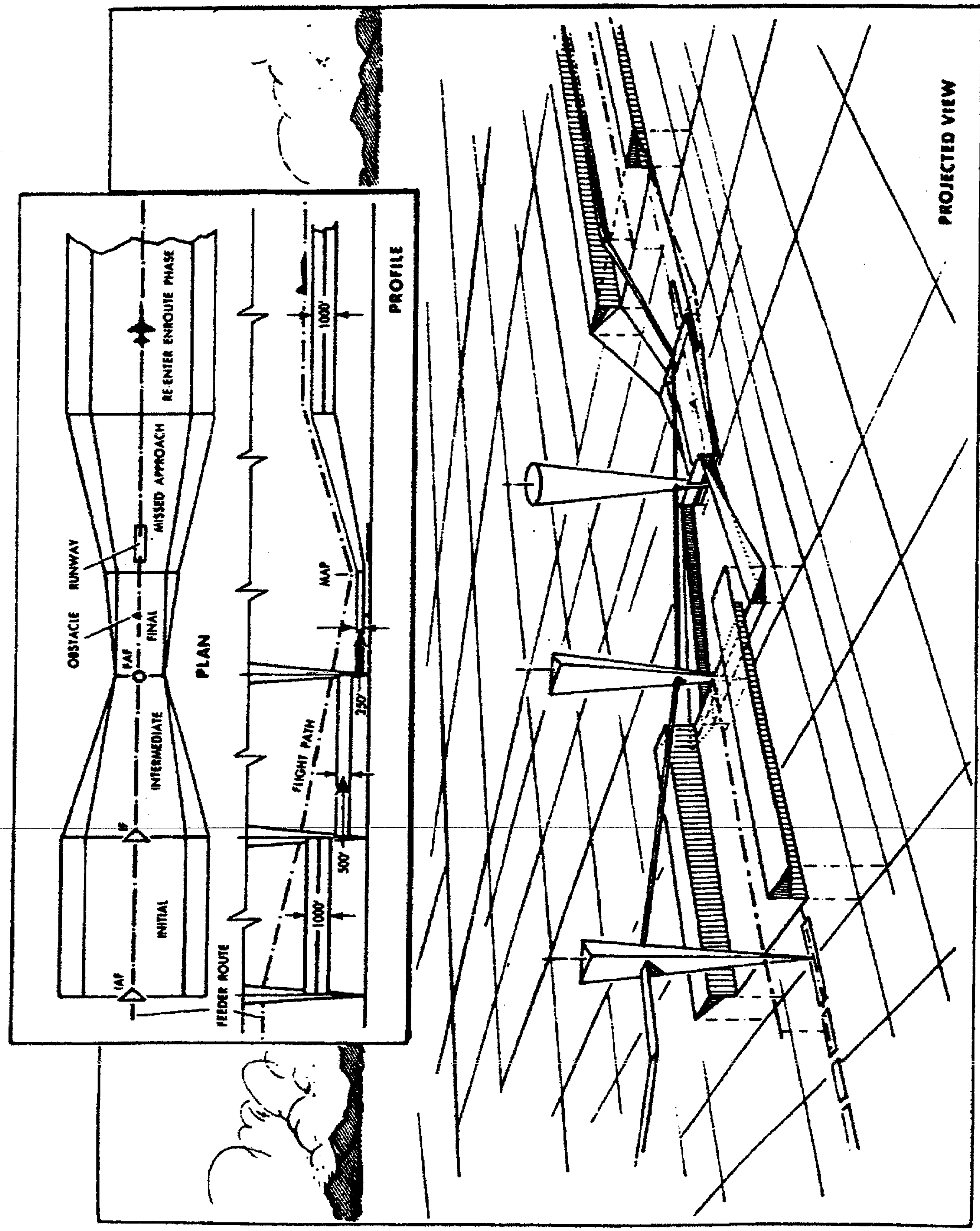
211. POSITIVE COURSE GUIDANCE (PCG). PCG must be provided for feeder routes, initial (except as provided for in paragraph 233b), intermediate, and final approach segments. The segments of a procedure wherein PCG is provided should be within the service volume of the facility(ies) used, except where Expanded Service Volume (ESV) has been authorized. PCG may be provided by one or more of the navigation systems for which criteria has been published.

212. APPROACH CATEGORIES (CAT). Aircraft performance differences have an effect on the airspace and visibility needed to perform certain maneuvers. Because of these differences, aircraft manufacturer/operational directives assign an alphabetical category to each aircraft so that the appropriate obstacle clearance areas and landing and departure minimums can be established in accordance with the criteria in this order. The categories used and referenced throughout this order are Category A, B, C, D, and/or E. Aircraft categories are defined in Part 97.

213. APPROACH CATEGORY APPLICATION. The approach category operating characteristics must be used to determine turning radii minimums and obstacle clearance areas for circling and missed approaches.

214. PROCEDURE CONSTRUCTION. An IAP may have four separate segments. They are the initial, intermediate, final, and missed approach segments. In addition, an area for circling the airport under visual conditions shall be considered. An approach segment begins and ends at the plotted position of the fix; however, under some circumstances certain segments may begin at specified points where no fixes are available. The fixes are named to coincide with the associated segment. For example, the intermediate segment begins at the intermediate fix (IF) and ends at the final approach fix (FAF). The order in which this chapter discusses the segments is the same order in which the pilot would fly them in a completed procedure; that is from an initial, through an intermediate, to a final approach. In constructing the procedure, the FAC should be identified first because it is the least flexible and most critical of all the segments. When the final approach has been determined, the other segments should be blended with it to produce an orderly maneuvering pattern, which is responsive to the local traffic flow. Consideration must also be given to any accompanying controlled airspace requirements in order to conserve airspace to the extent it is feasible (see figure 1-4).

Figure 1-4. SEGMENTS OF AN APPROACH PROCEDURE. Par 214.



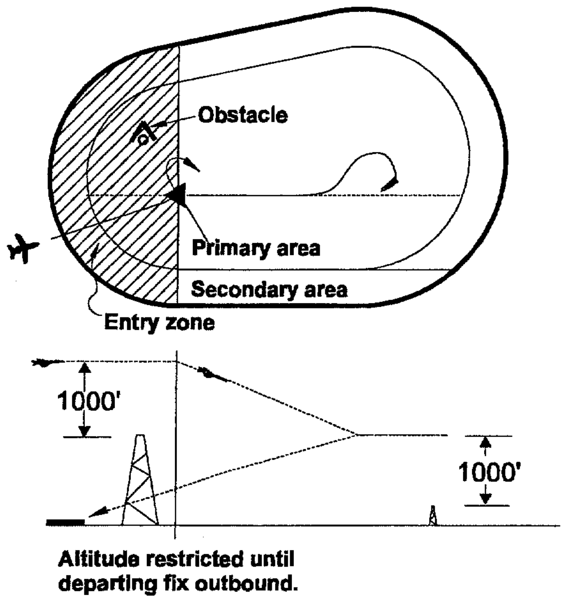


Figure 6. PT INITIAL APPROACH AREA. Par 234c.

e. **Elimination of PT.** A PT is NOT required when an approach can be made direct from a specified IF to the FAF. A PT NEED NOT be established when an approach can be made from a properly aligned holding pattern. See paragraph 291. In this case, the holding pattern in lieu of a PT, shall be established over a final or intermediate approach fix and the following conditions apply:

(1) **If the holding pattern** is established over the FAF (not applicable to RNAV procedures), an intermediate segment is not constructed. Ideally, establish the minimum holding altitude at the FAF altitude. In any case, the published holding altitude shall not be more than 300 feet above the FAF altitude.

(2) **If the holding pattern** is established over the IF, the MHA shall permit descent to the FAF altitude within the descent gradient tolerances prescribed for the intermediate segment (see paragraph 242d).

Table 1B. PT COMPLETION ALTITUDE DIFFERENCE. Par 234d.

TYPE OF PT	ALTITUDE DIFFERENCE
15 Mile PT from FAF	Within 3,000 Ft of Alt. over FAF
10 Mile PT from FAF	Within 2,000 Ft of Alt. over FAF
5 Mile PT from FAF	Within 1,000 Ft of Alt. over FAF
15 Mile PT, no FAF	Not Authorized
10 Mile PT, no FAF	Within 1,500 Ft of MDA on Final
5 Mile PT, no FAF	Within 1,000 Ft of MDA on Final

235. INITIAL APPROACH BASED ON HIGH ALTITUDE TEARDROP PENETRATION. A teardrop penetration consists of departure from an IAF on an outbound course, followed by a turn toward and intercepting the inbound course at or prior to the IF or point. Its purpose is to permit an aircraft to reverse direction and lose considerable altitude within reasonably limited airspace. Where no IF is available to mark the beginning of the intermediate segment, it shall be assumed to commence at a point 10 miles prior to the FAF. When the facility is located on the airport, and no fix is available to mark the beginning of the final approach segment, the criteria in paragraph 423 apply.

a. **Alignment.** The outbound penetration course shall be between 18° and 26° to the left or right of the reciprocal of the inbound course. The actual angular divergence between the courses will vary inversely with the distance from the facility at which the turn is made (see table 2).

b. **Area.**

(1) **Size.** The size of the penetration turn area must be sufficient to accommodate both the turn and the altitude loss required by the procedure. The penetration turn distance shall not be less than 20 miles from the facility. The penetration turn distance depends on the altitude to be lost in the procedure and the point at which the descent is started (see table 2). The aircraft should lose half the total altitude or 5,000 feet, whichever is greater, outbound prior to starting the turn. The penetration turn area has a width of 6 miles on both sides of the flight track up to the IF or point, and shall encompass all the areas within the turn (see figure 7).

Table 2. PENETRATION TURN DISTANCE/DIVERGENCE. Par 235a.

ALT TO BE LOST PRIOR TO COMMENCING TURN	DISTANCE TURN COMMENCES (NM)	COURSE DIVERGENCE (DEGREES)	SPECIFIED PENETRATION TURN DISTANCE (NM)
12,000 Ft	24	18	28
11,000 Ft	23	19	27
10,000 Ft	22	20	26
9,000 Ft	21	21	25
8,000 Ft	20	22	24
7,000 Ft	19	23	23
6,000 Ft	18	24	22
5,000 Ft	17	25	21
5,000 Ft	16	26	20

(2) **Penetration Turn Table.** Table 2 should be used to compute the desired course divergence and penetration turn distances which apply when a specific

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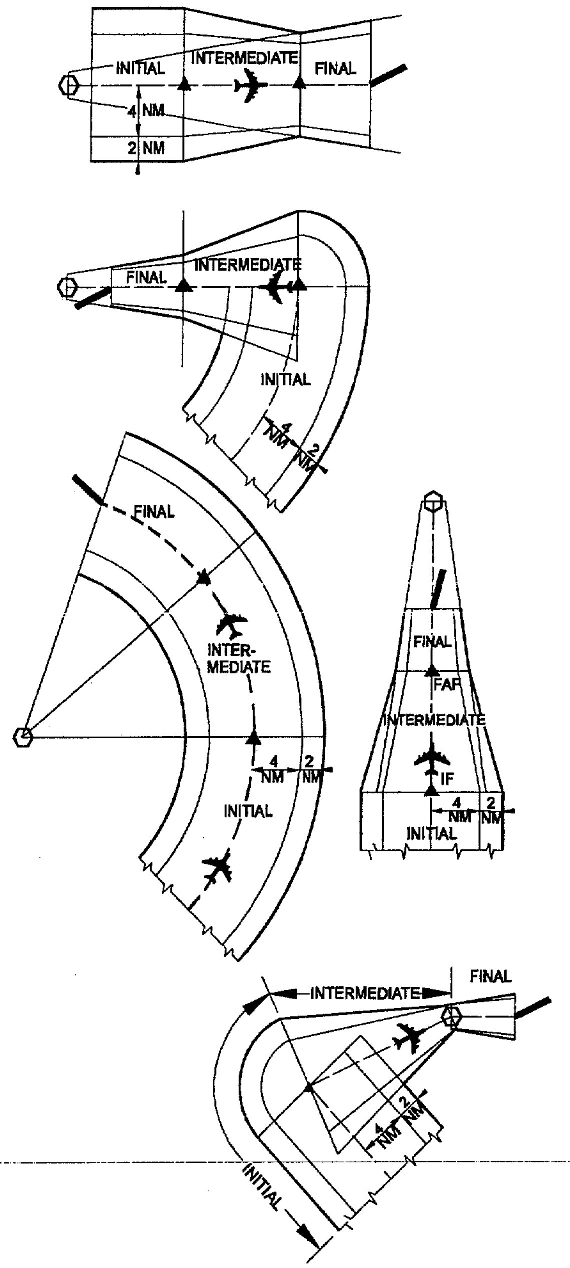


Figure 10. TYPICAL APPROACH SEGMENTS. Par 232b and 240.

242. INTERMEDIATE APPROACH SEGMENT BASED ON STRAIGHT COURSES.

a. Alignment. The course to be flown in the intermediate segment shall be the same as the FAC, except when the FAF is the navigation facility and it is not practical for the courses to be identical. In such cases, the intermediate course shall not differ from the FAC by more than 30°.

b. Area.

(1) Length. The length of the intermediate segment is measured along the course to be flown. Where the initital segment joins the intermediate segment at angles up to 90 degrees, the MINIMUM length is 5 NM for CAT A/B, and 6 NM for CAT C/D/E (except as specified in Volume 1, chapters 9 and 10, and Volume 3, chapter 2). Table 3 lists the minimum segment length where the intial approach course joins the intermediate course at an angle greater than 90 degrees (see figure 3). The MAXIMUM segment length is 15 NM. The OPTIMUM length is 10 NM. A distance greater than 10 NM should not be used unless an operational requirement justifies a greater distance.

(2) Width. The width of the intermediate segment is the same as the width of the segment it joins. When the intermediate segment is aligned with initial or final approach segments, the width of the intermediate segment is determined by joining the outer edges of the initial segment with the outer edges of the final segment. When the intermediate segment is not aligned with the initial or final approach segments, the resulting gap on the outside of the turn is a part of the preceding segment and is closed by the appropriate arc (See figure 10). For obstacle clearance purposes, the intermediate segment is divided into a primary and a secondary area.

Table 3. MINIMUM INTERMEDIATE COURSE LENGTH. Par 242b(1).

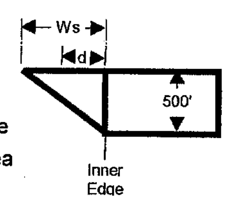
ANGLE (DEGREES)	MINIMUM LENGTH (MILES) Cat A/B	C/D/E
>90 - 96	5	6
>96 - 102	6	7
>102 - 108	6	8
>108 - 114	6	9
>114 - 120	7	10

c. Obstacle Clearance. A MINIMUM of 500 feet of obstacle clearance shall be provided in the primary area of the intermediate approach segment. In the secondary area, 500 feet of obstacle clearance shall be provided at the inner edge, tapering to zero feet at the outer edge.

$$\text{Secondary ROC} = 500 \times \frac{Ws - d}{Ws}$$

Where d = distance from inner edge

Ws = Width of secondary area



Allowance for precipitous terrain should be considered as specified in paragraph 323a. The altitudes selected by application of the obstacle clearance specified in this paragraph may be rounded to the nearest 100 feet (see paragraph 241).

d. Descent Gradients. Because the intermediate segment is used to prepare the aircraft speed and configuration for entry into the final approach segment, the gradient should be as flat as possible. The OPTIMUM descent gradient is 150 feet per mile. The MAXIMUM gradient is 318 feet per mile, except for a localizer approach published in conjunction with an ILS procedure. In this case, a higher descent gradient equal to the commissioned GS angle (provided it does not exceed 3°) is permissible. Higher gradients resulting from arithmetic rounding are also permissible.

NOTE: When the descent gradient exceeds 318 feet per mile, the procedure specialist should assure a segment is provided prior to the intermediate segment to prepare the aircraft speed and configuration for entry into the final segment. This segment should be a minimum length of 5 miles and its descent gradient should not exceed 318 feet per mile.

243. INTERMEDIATE APPROACH SEGMENT BASED ON AN ARC. Arcs with a radius of less than 7 miles or more than 30 miles from the navigation facility shall NOT be used. DME arc courses shall be predicated on DME collocated with a facility providing omnidirectional course information.

a. Alignment. The same arc shall be used for the intermediate and the final approach segments. No turns shall be required over the FAF.

b. Area.

(1) Length. The intermediate segment shall NOT be less than 5 miles nor more than 15 miles in length, measured along the arc. The OPTIMUM length is 10 miles. A distance greater than 10 miles should not be used unless an operational requirement justifies the greater distance.

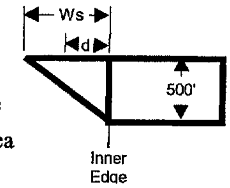
(2) Width. The total width of an arc intermediate segment is 6 miles on each side of the arc. For obstacle clearance purposes, this width is divided into a primary and a secondary area. The primary area extends 4 miles laterally on each side of the arc segment. The secondary areas extend 2 miles laterally on each side of the primary area (see figure 10).

c. Obstacle Clearance. A MINIMUM of 500 feet of obstacle clearance shall be provided in the primary area. In the secondary area, 500 feet of obstacle clearance shall be provided at the inner edge, tapering to zero feet at the outer edge.

$$\text{Secondary ROC} = 500 \times \frac{Ws - d}{Ws}$$

Where d = distance from inner edge

Ws = Width of secondary area



Allowance for precipitous terrain should be considered as specified in paragraph 323a. The altitudes selected by application of the obstacle clearance specified in this paragraph may be rounded to the nearest 100 feet (see paragraph 241).

d. Descent Gradients. Criteria specified in paragraph 242d shall apply.

244. INTERMEDIATE APPROACH SEGMENT WITHIN A PT.

a. PT Over a FAF. When the FAF is a facility (see figure 11).

(1) The MAXIMUM intermediate length is 15 NM, the OPTIMUM is 10 NM, and the MINIMUM is 5 NM. Its width is the same as the final segment at the facility and expanding uniformly to 6 NM on each side of the course at 15 NM from the facility.

(2) The intermediate segment considered for obstacle clearance shall be the same length as the PT distance; e.g., if the procedure requires a PT to be completed within 5 NM, the intermediate segment shall be only 5 NM long, and the intermediate approach shall begin on the intermediate course 5 NM from the FAF.

(3) When establishing a stepdown fix within an intermediate/initial segment underlying a PT area:

(a) Table 1A shall be applied.

(b) Only one stepdown fix is authorized within the intermediate segment that underlies the PT maneuvering area.

(c) The distance between the PT fix/facility and a stepdown fix underlying the PT area shall not exceed 4 NM.

(d) The MAXIMUM descent gradient from the IF point to the stepdown fix is 200 feet/NM. The MAXIMUM descent gradient from the stepdown fix to the FAF is 318 feet/NM.

(3) **Intermediate Segment Area.**

(a) PT Over a Facility. The intermediate segment starts 15 NM from the facility at a width of 6 NM each side of the inbound course and connects to the width of the final segment at the FAF. The area considered for obstacle clearance is from the start of the PT distance to the FAF.

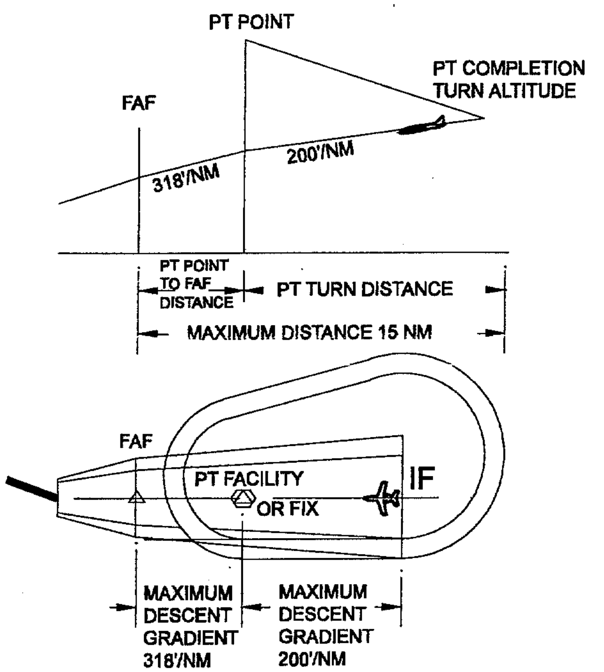


Figure 14-2. INTERMEDIATE AREA WITHIN PT AREA. PT Facility/Fix Used as a Stepdown Fix. Par 244d(4).

(b) PT Over a Fix (NOT a Facility). The intermediate segment starts at the PT distance at a width of 6 NM each side of the inbound course and connects to the width of the final segment at the FAF. The area considered for obstacle clearance is from the start of the PT distance to the FAF.

(4) **The MAXIMUM descent gradient** is 200 feet/NM. If the PT facility/fix is a stepdown fix, the descent gradient from the stepdown fix to the FAF may be increased to a maximum of 318 feet/NM (see figure 14-2). The PT distance may be increased in 1 NM increments up to 15 NM to meet descent limitations.

(5) **When establishing a stepdown fix** within an intermediate/initial segment underlying a PT area:

(a) When the PT fix is over a facility/fix prior to the FAF, the facility/fix is the stepdown fix in the intermediate/initial area, and another stepdown fix within this segment is not authorized.

(b) The MAXIMUM descent gradient from the IF point to the stepdown fix is 200 feet/NM. The MAXIMUM descent gradient from the stepdown fix to the FAF is 318 feet/NM.

e. **PT Facility Fix Used as an IF.** See figure 14-3.

(1) **When the PT inbound course** is the same as the intermediate course, either paragraph 244d may be used, or a straight initial segment may be used from the start of the PT distance to the PT fix.

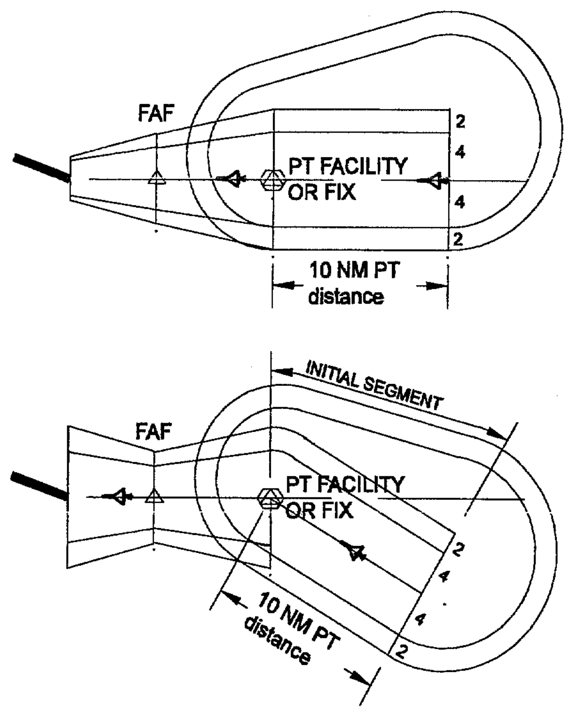


Figure 14-3. USE OF PT FIX FOR IF. Par 244e.

(2) **When the PT inbound course** is NOT the same as the intermediate course, an intermediate segment within the PT area is NOT authorized; ONLY a straight initial segment shall be used from the start of the PT distance to the PT fix.

(3) **When a straight initial segment** is used, the MAXIMUM descent gradient within the PT distance is 318 feet/NM, the PT distance may be increased in 1 NM increments up to 15 NM to meet descent limitations.

(4) **When establishing a stepdown fix** within an intermediate/initial segment underlying a PT area:

(a) Only one stepdown fix is authorized within the initial segment that underlies the PT maneuvering area.

(b) The distance from the PT facility/fix and a stepdown fix underlying the PT area shall not exceed 4 NM.

(c) The MAXIMUM descent gradient from the PT completion point (turn distance) to the stepdown fix, and from the stepdown fix to the IF, is 318 feet/NM.

f. When a PT from a facility is required to intercept a localizer course, the PT facility is considered on the localizer course when it is located within the commissioned localizer course width.

245.-249. RESERVED.

SECTION 5. FINAL APPROACH

250. FINAL APPROACH SEGMENT. This is the segment in which alignment and descent for landing are accomplished. The final approach segment considered for obstacle clearance begins at the FAF or points and ends at the runway or missed approach point (MAP), whichever is encountered last. A visual portion within the final approach segment may be included for straight-in nonprecision approaches (see paragraph 251). Final approach may be made to a runway for a straight-in landing or to an airport for a circling approach. Since the alignment and dimensions of the non-visual portions of the final approach segment vary with the location and type of navigation facility, applicable criteria are contained in chapters designated for specific navigation facilities.

251. VISUAL PORTION OF THE FINAL APPROACH SEGMENT. Evaluate the visual area associated with each usable runway at an airport. Apply the STANDARD visual area described in paragraph 251a(1) to runways to which an aircraft is authorized to circle. Apply the STRAIGHT-IN area described in paragraph 251a(2) to runways with approach procedures aligned with the runway centerline. Apply the OFFSET visual area described in para-graph 251a(3) to evaluate the visual portion of a straight-in approach that is not aligned with the runway centerline. These evaluations determine if night operations must be prohibited because of close-in unlighted obstacles or if visibility minimums must be restricted.

NOTE: If a runway is served by an approach procedure not aligned with the runway centerline, and is authorized for landing from a circling maneuver on an approach procedure to a different runway, it will receive both standard and offset evaluations.

a. Area.

(1) Standard.

(a) Alignment. Align the visual area with the runway centerline extended.

(b) Length. The visual area begins 200 feet from the threshold (THR) at THR elevation and extends 10,000 feet out the runway centerline (see figure 14-4).

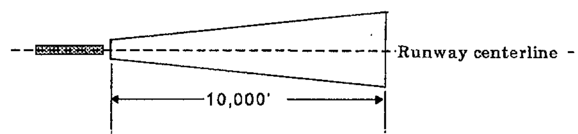


Figure 14-4. VISUAL AREA, Par. 251a(1)(b)

(c) Width. The beginning width of the visual area is 400 feet (200 feet either side of runway centerline) (see figure 14-5). The sides splay outward relative to runway centerline. Calculate the width of the area at any distance "d" from its origin using the following formula:

$$\tfrac{1}{2}W = (0.15 \times d) + 200'$$

where ½W = Perpendicular distance from centerline to edge of area
d = Distance (ft) measured along centerline from area origin

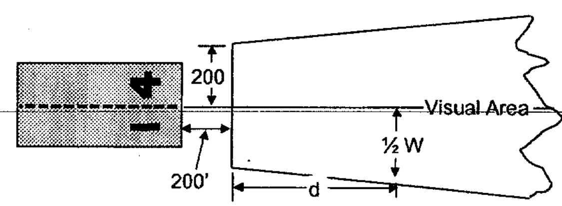


Figure 14-5. VISUAL AREA ORIGIN, Par 251a(1)(c).

(2) Straight-in. (Need not meet straight-in descent criteria.)

(a) Alignment. Align the visual area with the runway centerline extended.

(b) Length. The visual area begins 200 feet from the threshold (THR) at THR elevation, and extends to the DH point for precision procedures or to the VDP location (even if one is not published) for nonprecision procedures (see paragraph 253).

NOTE: When more than one set of minimums are published, use the lowest MDA to determine VDP location.

(c) Width. The beginning width of the visual area is 800 feet (400 feet either side of runway centerline). The sides splay outward relative to runway centerline (see figure 14-6). Calculate the width of the area at any distance "d" from its origin using the following formula:

$$\tfrac{1}{2}W = (0.138 \times d) + 400$$

Where ½W = Perpendicular distance in feet from centerline to edge of area

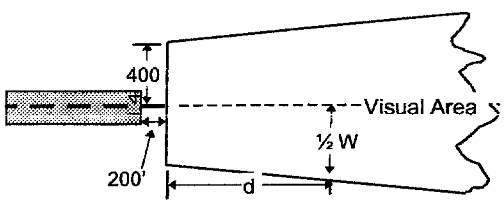


Figure 14-6 VISUAL AREA ORIGIN, Par 251a(2).

(3) Offset. When the final course does not coincide with the runway centerline extended (± 0.05°), modify the visual area as follows: (See figure 14-6A)

(a) STEP 1. Draw the area aligned with the runway centerline as described in paragraph 251a(2).

(b) STEP 2. Extend a line perpendicular to the final approach course (FAC) from the visual descent point (VDP) (even if one is not published) to the point it crosses the runway centerline (RCL) extended .

(c) STEP 3. Extend a line from this point perpendicular to the RCL to the outer edge of the visual area, noting the length (L) of this extension.

(d) STEP 4. Extend a line in the opposite direction than the line in Step 2 from the VDP perpendicular to the FAC for the distance (L).

(e) STEP 5. Connect the end of the line constructed in Step 4 to the end of the inner edge of the area origin line 200 feet from runway threshold.

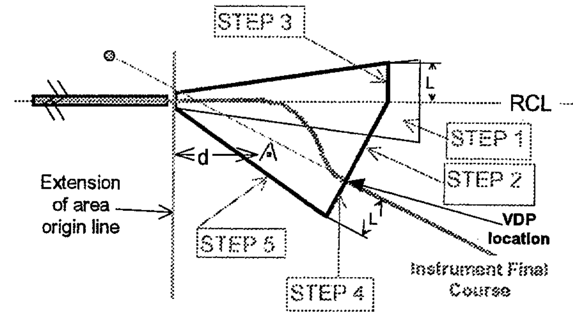


Figure 14-6A. VISUAL SEGMENT FOR OFFSET COURSE, Par 251a(3).

b. Obstacle Clearance. Two obstacle identification surfaces (OIS) overlie the visual area with slopes of 20:1 and 34:1, respectively. When evaluating a runway for circling, apply the 20:1 surface. When evaluating a runway for an approach procedure satisfying straight-in alignment criteria, apply the 20:1 and 34:1 surfaces. Calculate the surface height above threshold at any distance "d" from an extension of the area origin line using the following formulae:

$$20{:}1 \text{ Surface Height} = \frac{d}{20}$$

$$34{:}1 \text{ Surface Height} = \frac{d}{34}$$

(1) If the 34:1 surface is penetrated, take **ONE** of the following actions:

(a) Adjust the obstacle height below the surface or remove the penetrating obstacles.

(b) Limit minimum visibility to ¾ mile.

(2) In addition to the 34:1 evaluation, if the straight-in runway's 20:1 surface is penetrated, take **ONE** of the following actions:

(a) Adjust the obstacle height below the surface or remove the penetrating obstacles.

(b) Do not publish a VDP, limit minimum visibility to 1 mile, and take action to have the penetrating obstacles marked and lighted.

(c) Do not publish a VDP, limit minimum visibility to 1 mile, and publish a note denying the approach (both straight-in and circling) to the affected runway at night.

(3) If the 20:1 surface is penetrated on circling runways, mark and light the penetrating obstacles or publish a note denying night circling to the affected runway.

252. DESCENT ANGLE / GRADIENT. The OPTIMUM nonprecision final segment descent gradient is 318 ft/NM which approximates a 3.00° angle. The MAXIMUM descent gradient is 400 ft/NM which approximates a descent angle of 3.77°. Calculate descent gradients from the plotted position of the FAF or stepdown fix to the plotted position of a stepdown fix or final endpoint (FEP) as appropriate (see figure 14-7). The FEP is formed by the intersection of the final approach course (FAC) and a line perpendicular to the FAC that extends through the runway threshold (first usable landing surface for circling only procedures). When the maximum descent gradient is exceeded, straight-in minimums are NOT authorized; however, circling only minimums may be authorized if the maximum circling descent gradient is not exceeded (see paragraph 252d). In these cases, publish the actual descent gradient to TCH rather than to CMDA.

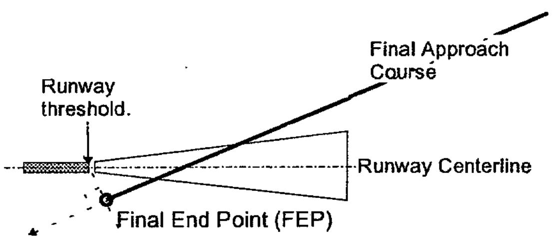


Figure 14-7. FINAL END POINT, Par 252.

a. Non-RNAV Approaches. FAF and/or last stepdown fix (SDF) location and altitude should be selected to provide a descent angle and TCH coincident (±0.20°, ± 3′) with the lowest published visual glide slope indicator (VGSI) glide slope angle, when feasible; or, when VGSI is not installed, the FAF and/or last SDF location and altitude should be selected so as to achieve a near optimum final segment descent gradient. To determine the FAF or SDF altitude necessary to align the descent angle with the lowest VGSI, calculate the altitude gain of a plane with the slope of the lowest published VGSI glide slope angle emanating from the lowest published VGSI threshold crossing height (TCH) to the FAF or SDF location. To determine the OPTIMUM FAF or SDF altitude, calculate the altitude gain of a 318 ft/NM gradient (3° angle) extending from the visual TCH (when there is not a VGSI, see table 18A) to the FAF or SDF location. Round this altitude up or down to the 100′ increment for the FAF or 20' increment for the SDF. Ensure that ROC requirements are not violated during the rounding process. If the gradient from TCH to SDF is greater than the gradient from TCH to FAF, continue the greater gradient to the FAF and adjust the FAF altitude accordingly. If ATC application of hold-in-lieu of PT criteria in paragraph 234e(1) or intermediate segment obstacles prohibit this altitude, consider relocating the FAF to achieve an altitude that will satisfy these requirements and the VGSI or optimum descent gradient (see figure 14-8).

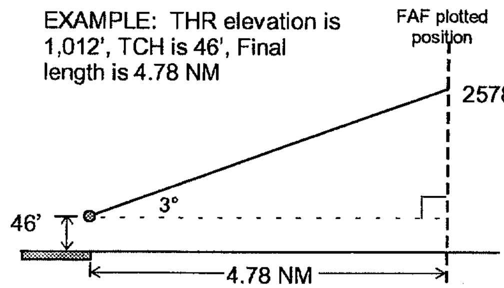
SL in NM:

$$FAF\ \text{Altitude} = \text{THRe} + \text{TCH} + (318 \times SL)$$

SL in feet:

$$\text{FAF Altitude} = \text{THRe} + \text{TCH} + (\tan(\text{VGSI angle}) \times SL \times 6076.11548)$$

where: THRe = THR Elevation
SL = Segment Length



$$2578.04 = 1012 + 46 + (318 \times 4.78)$$

or

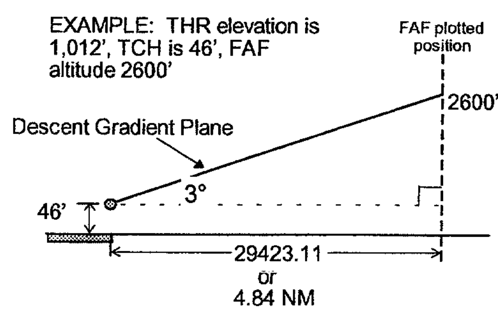
$$2580.12 = 1012 + 46 + \tan(3°) \times (4.78 \times 6076.11548)$$

Figure 14-8. FAF ACTIVITIES GIVEN FINAL LENGTH, Par 252a.

b. RNAV Approaches. If feasible, place the FAF waypoint where the optimum descent angle, or the lowest published VGSI (if installed) glidepath angle intersects the intermediate altitude or the altitude determined by application hold-in-lieu of PT criteria in paragraph 234e(1). When an SDF is used, the SDF altitude should be at or below the published VGSI glide slope angle (lowest angle for multi-angle systems). See figure 14-9.

$$SL = \frac{(\text{FAF Altitude} - [\text{THRe} + \text{TCH}])}{\tan(3° \text{ or VGSI angle})}$$

where: SL = Segment Length in feet
THRe = Threshold Elevation



$$29423.11 = \frac{2600 - (1012 + 46)}{\tan(3°)}$$

Figure 14-9. FINAL LENGTH GIVEN FAF ALTITUDE, Par 252b.

c. Determining Final Segment Descent Gradient and Angle.

(1) Final Without Stepdown Fixes. Calculate the final descent gradient by dividing the height loss from FAF to TCH by the segment length in NM.

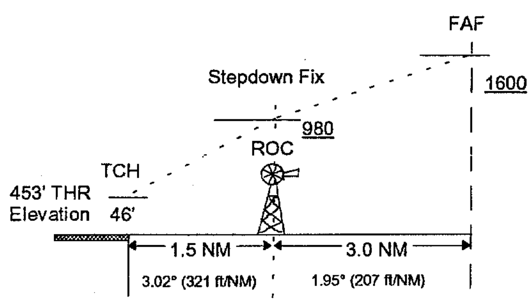
$$\text{Descent Gradient} = \frac{\text{Height Loss}}{\text{Segment Length (NM)}}$$

The descent gradient divided by 6076.11548 is the tangent of the segment descent angle(θ).

$$\text{Tan}(\theta) = \frac{\text{Descent Gradient}}{6076.11548}$$

For RNAV SIAP's, this angle is the glide slope computer setting.

(2) Final With Stepdown Fix. The maximum descent angle is calculated using the difference between the FAF/stepdown altitude and the stepdown/TCH altitude as appropriate. Descent gradient and angle computations apply to each stepdown segment. Height loss in the last segment flown is from the stepdown fix minimum altitude to the TCH (see figure 14-10).



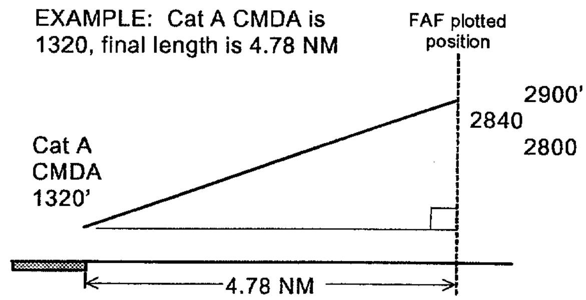
$$\text{Descent Gradient} = \frac{(1600 - 980)}{3.0}$$
$$\text{Descent Gradient} = 207 \text{ ft / NM}$$
$$\text{Tan}(\theta) = \frac{207}{6076.11548}$$
$$\theta = 1.95°$$

$$\text{Descent Gradient} = \frac{(980 - (453 + 46))}{1.5}$$
$$\text{Descent Gradient} = 321 \text{ ft / NM}$$
$$\text{Tan}(\theta) = \frac{321}{6076.11548}$$
$$\theta = 3.02°$$

Figure 14-10. DESCENT GRADIENT AND ANGLE, Par 252c(2).

d. Circling Approaches. The maximum descent angle is calculated using the difference between the FAF/stepdown altitude and stepdown/lowest circling minimum descent altitude (CMDA) as appropriate (see figure 14-11).

FAF Altitude = CMDA + (318 x Seg. Len. in NM)



To calculate FAF altitude for a given descent gradient:
$2840.04 = 1320 + (318 \times 4.78)$

Figure 14-11, FAF NET GIVEN SEGMENT LENGTH, Par 252d.

To calculate Descent Gradient and Angle given a FAF altitude and final length:

$$\text{Descent Gradient} = \frac{(2900 - 1320)}{4.78}$$
$$\text{Descent Gradient} = 331$$
$$\text{Tan}(\theta) = \frac{331}{6076.11548}$$
$$\theta = 3.12°$$

253. VISUAL DESCENT POINT (VDP) (applicable to straight-in procedures only). When dual minimums are published, use the lowest minimum descent altitude (MDA) to calculate the VDP distance. **PUBLISH A VDP FOR ALL STRAIGHT-IN NONPRECISION APPROACHES** except as follows:

- Do not publish a VDP associated with an MDA based on part-time or full time remote altimeter settings.
- Do not publish a VDP located prior to a stepdown fix.
- If the VDP is between the MAP and the runway, do not publish a VDP.

a. For runways served by a VGSI, using the VGSI TCH, establish the distance from THR to a point where the lowest published VGSI glidepath angle reaches an altitude equal to the MDA. Use the following formula:

$$\text{VDP Distance} = \frac{\text{MDA} - (\text{TCH} + \text{THR Elevation})}{\text{Tan}(\text{VGSI Angle})}$$

b. For runways NOT served by a VGSI, using an appropriate TCH from table 18A, establish the distance from THR to a point where the greater of a 3° or the final segment descent angle reaches the MDA. Use the following formula:

$$\textit{VDP}\text{ Distance} = \frac{\text{MDA} - (\text{TCH} + \text{THR Elevation})}{\text{Tan}(^{*}\text{ Angle})}$$

* final segment descent angle or 3°, whichever is higher.

c. Marking VDP Location.

(1) For Non-RNAV SIAP's, mark the VDP location with a DME fix. The DME must be collocated with the facility providing final approach course guidance (USN/USA/USAF NA). If DME is not available, do not establish a VDP. Maximum fix error is ± 0.5 NM.

(2) For RNAV SIAP's, mark the VDP location with an along track distance (ATD) fix to the MAP. Maximum fix error is ± 0.5 NM.

(3) If the final course is not aligned with the runway centerline, use the THR as a vertex, swing an arc of a radius equal to the VDP distance across the final approach course (see figure 14-12). The point of inter-section is the VDP. (For RNAV procedures, the distance from the point of intersection to the MAP is the ATD for the VDP.)

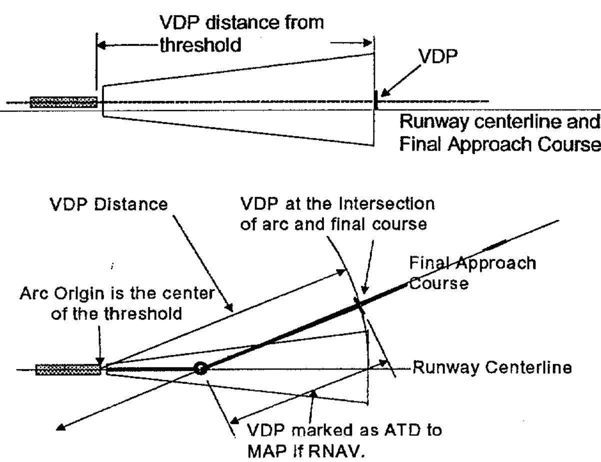


Figure 14-12. VDP LOCATION, Par 253c(3).

254.-259. RESERVED.

SECTION 6. CIRCLING APPROACH

260. CIRCLING APPROACH AREA. This is the obstacle clearance area which shall be considered for aircraft maneuvering to land on a runway which is not aligned with the FAC of the approach procedure.

a. Alignment and Area. The size of the circling area varies with the approach category of the aircraft, as shown in table 4. To define the limits of the circling area for the appropriate category, draw an arc of suitable radius from the center of the end of each usable runway. Join the extremities of the adjacent arcs with lines drawn tangent to the arcs. The area thus enclosed is the circling approach area (see figure 15).

Table 4. CIRCLING APPROACH AREA RADII. Par 260a.

Approach Category	Radius (Miles)
A	1.3
B	1.5
C	1.7
D	2.3
E	4.5

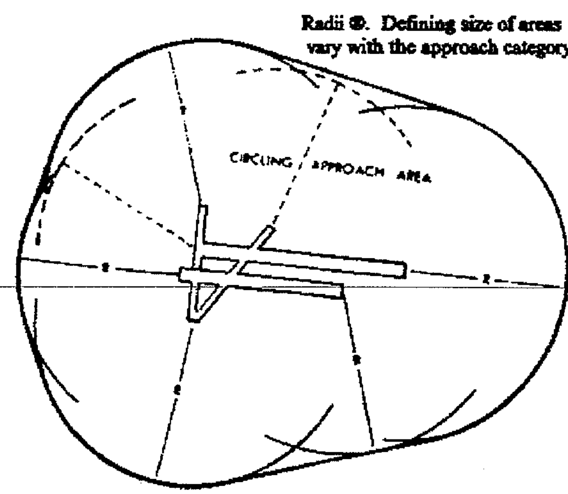


Figure 15. CONSTRUCTION OF CIRCLING APPROACH AREA. Par 260a.

b. Obstacle Clearance. A minimum of 300 feet of obstacle clearance shall be provided in the circling segment at a point 15 flying miles from the MAP. When PCG is available, a secondary area for the reduction of obstacle clearance is identified within the missed approach area. It has the same width as the final approach secondary area at the MAP, and expands uniformly to a width of 2 miles at a point 15 miles from the MAP (see figure 16). Where PCG is not available beyond this point, expansion of the area continues until PCG is achieved or segment terminates. Where PCG is available beyond this point, the area tapers at a rate of 30° inward relative to the course until it reaches initial segment width.

NOTE: Only the primary missed approach procedure shall be included on the published chart.

271. MISSED APPROACH ALIGNMENT. Wherever practical, the missed approach course should be a continuation of the FAC. Turns are permitted, but should be minimized in the interest of safety and simplicity.

272. MAP. The MAP specified in the procedure may be the point of intersection of an electronic glidepath with a DH, a navigation facility, a fix, or a specified distance from the FAF. The specified distance may not be more than the distance from the FAF to the usable landing surface. The MAP shall **NOT** be located prior to the VDP. Specified criteria for the MAP are contained in the appropriate facility chapters.

273. STRAIGHT MISSED APPROACH AREA. When the missed approach course is within 15° of the final approach course, it is considered a straight missed approach (see figure 16). The area considered for obstacle evaluation is specified in paragraph 270.

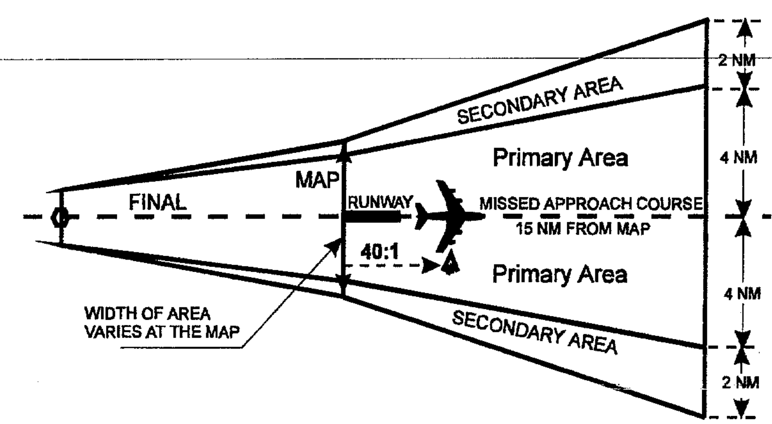


Figure 16. STRAIGHT MISSED APPROACH AREA. Par 270 and 273.

274. STRAIGHT MISSED APPROACH OBSTACLE CLEARANCE. Within the primary missed approach area, no obstacle shall penetrate the missed approach surface. This surface begins over the MAP at a height determined by subtracting the required final approach ROC and any minima adjustments, per paragraph 323 from the MDA. It rises uniformly at a rate of 1 foot vertically for each 40 feet horizontally (40:1). See figure 17. Where the 40:1 surface reaches a height of 1,000 feet below the missed approach altitude (paragraph 270), further application of the surface is not required. In the secondary area, no obstacle may penetrate a 12:1 slope that extends outward and upward from the 40:1 surface at the inner boundaries of the secondary area. See figure 18. Evaluate the missed approach segment to ensure obstacle clearance is provided.

a. Evaluate the 40:1 surface from the MAP to the clearance limit (end of the missed approach segment). The height of the missed approach surface over an obstacle is determined by measuring the straight-line distance from the obstacle to the nearest point on the line defining the origin of the 40:1 surface. If obstacles penetrate the surface, take action to eliminate the penetration.

b. The preliminary charted missed approach altitude is the highest of the minimum missed approach obstruction altitude, minimum holding altitude (MHA) established IAW paragraph 293a, or the lowest airway minimum en route altitude (MEA) at the clearance limit. To determine the minimum missed approach obstruction altitude for the missed approach segment, identify the highest obstacle in the primary area; or if applicable, the highest equivalent obstacle in the secondary area. Then add the appropriate ROC (plus adjustments) for holding or en route to the highest obstacle elevation. Round the total value to the nearest hundred-foot value.

c. Determine if a climbing in holding pattern (climb-in-hold) evaluation is required (see paragraph 293b). If a climb in holding is intended at the clearance limit, a climb-in-hold evaluation is mandatory.

(1) Calculate the elevation of the 40:1 surface at the end of the segment (clearance limit). The 40:1 surface starts at the same elevation as it does for obstacle evaluations. Compute the 40:1 rise from a point on the line defining the origin of the 40:1 surface in the shortest distance and perpendicular to the end-of-segment line at the clearance limit.

(2) Compute the ROC surface elevation at the clearance limit by subtracting the appropriate ROC (plus adjustments) from the preliminary charted missed approach altitude.

(3) Compare the ROC surface elevation at the clearance limit with the 40:1 surface elevation.

(a) If the computed 40:1 surface elevation is equal to or greater than the ROC surface elevation, a climb-in-hold evaluation is NOT required.

(b) If the computed 40:1 surface elevation is less than the ROC surface elevation, a climb-in-hold evaluation **IS** required. FAA Order 7130.3, Holding Pattern Criteria, paragraph 35, specifies higher speed groups and, therefore, larger template sizes are usually necessary for the climb-in-hold evaluation. These templates may require an increase in MHA under TERPS, paragraph 293a. If this evaluation requires an increase in the MHA, evaluate the new altitude using the higher speed group specified in paragraph 35. This sequence of review shall be used until the MHA does not increase, then the 40:1 surface is re-evaluated. If obstacles penetrate the 40:1 surface, take action to eliminate the penetration.

d. The charted missed approach altitude is the higher of the preliminary charted missed approach altitude or the MHA established under paragraph 274c(3)(b).

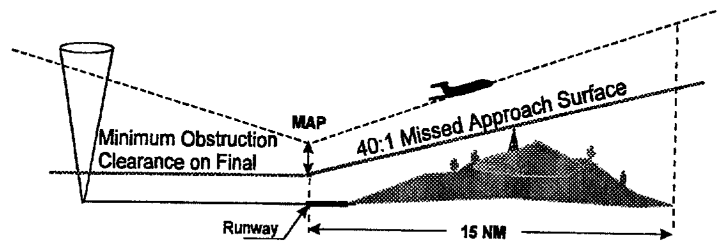
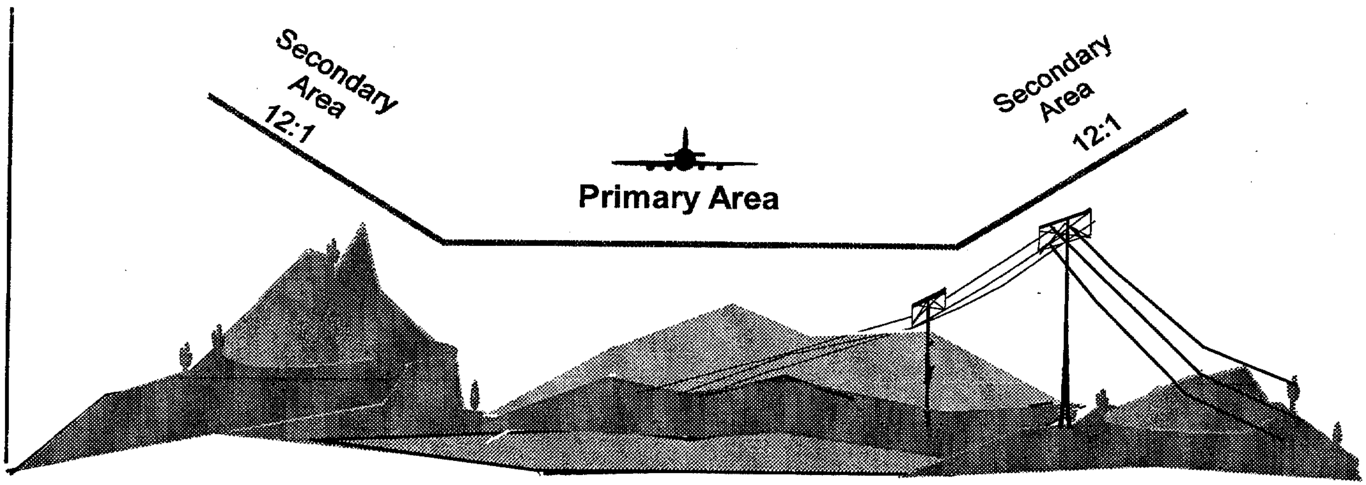


Figure 17. STRAIGHT MISSED APPROACH OBSTACLE CLEARANCE. Par 274.



WHEN COURSE GUIDANCE IS AVAILABLE

Figure 18. MISSED APPROACH CROSS SECTION. Par 274.

275. TURNING MISSED APPROACH AREA. (See Volume 3 for special provisions). If a turn of more than 15° from the FAC is required, a turning or combination straight and turning missed approach area must be constructed.

NOTE: If the HAT value associated with the DA/MDA is less than 400 feet, construct a combination straight and turning missed approach (see paragraph 277) to accommodate climb to 400 feet above touchdown zone elevation prior to turn.

a. The dimensions and shape of this area are affected by three variables:

(1) Width of final approach area at the MAP.

(2) All categories of aircraft authorized to use the procedure.

(3) Number of degrees of turn required by the procedure.

provided the angular divergence between the signal sources at the fix does not exceed 23° (see figure 28). For limitation on use of DME with ILS, see Volume 3, paragraph 2.9.1.

b. ATD Fixes. An ATD fix is an along track position defined as a distance in NM, with reference to the next WP along a specified course.

c. Fixes Formed by Marker Beacons. Marker beacons are installed to support certain NAVAID's that provide course guidance. A marker beacon is suitable to establish a fix only when it marks an along course distance from the NAVAID it is associated with; e.g. localizer and outer markers.

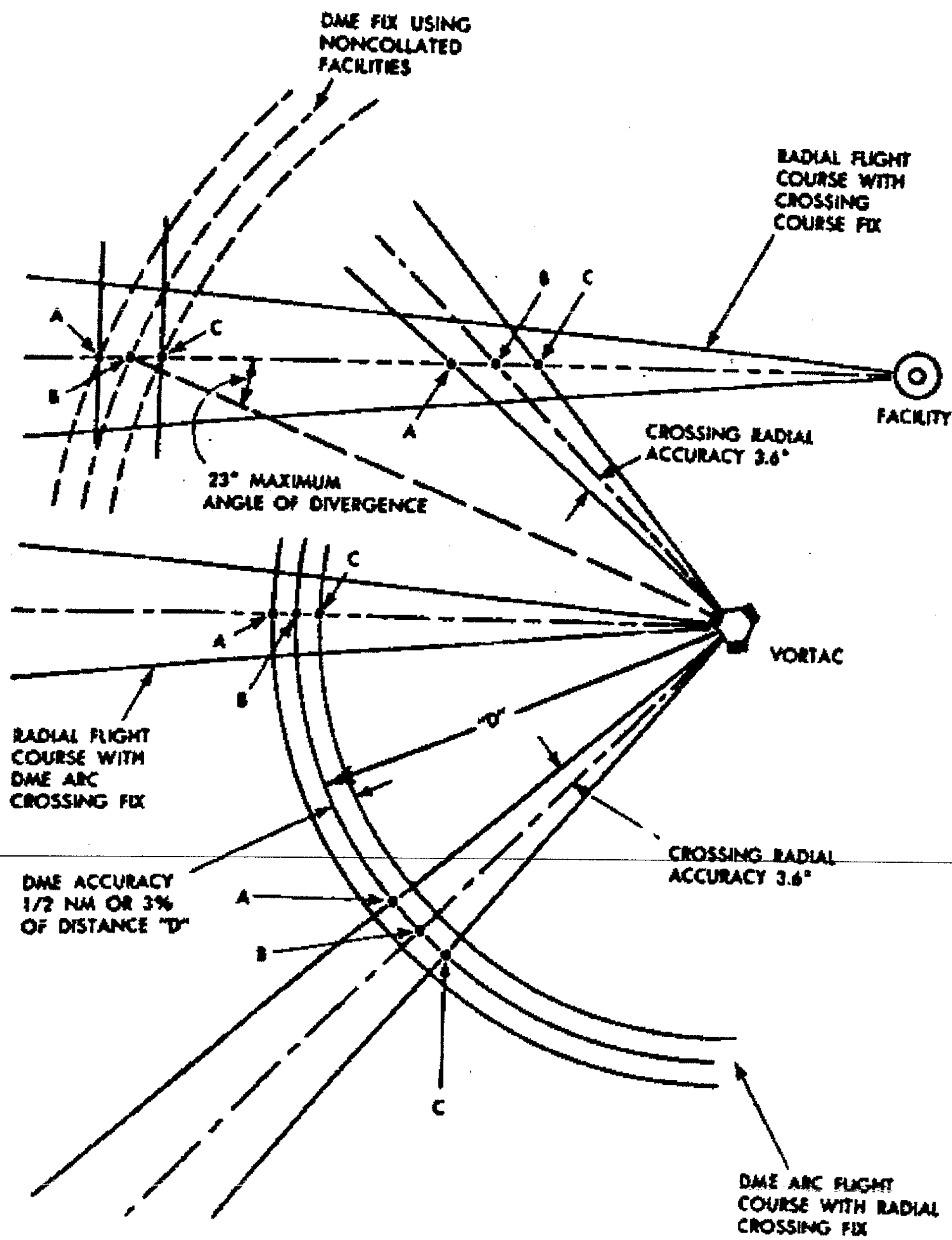


Figure 28. INTERSECTION FIX DISPLACEMENT. Par 281 and 282a.

283. FIXES FORMED BY RADAR. Where ATC can provide the service, Airport Surveillance Radar (ASR) may be used for any terminal area fix. PAR may be used to form any fix within the radar coverage of the PAR system. Air Route Surveillance Radar (ARSR) may be used for initial approach and intermediate approach fixes.

284. FIX DISPLACEMENT AREA. The areas portrayed in figure 28 extend along the flight course from point "A" to point "C". The fix error is a plus-or-minus value, and is represented by the lengths from "A" to "B" and "B" to "C". Each of these lengths is applied differently. The fix error may cause the fix to be received early (between "A" and "B"). Because the fix may be received early, protection against obstacles must be provided from a line perpendicular to the flight course at point "A".

285. INTERSECTION FIX DISPLACEMENT FACTORS. The intersection fix displacement area is determined by the system use accuracy of the navigation fixing systems (see figure 29). The system use accuracy in VOR and TACAN type systems is determined by the combination of ground station error, airborne receiving system error, and flight technical error (FTE). En route VOR data have shown that the VOR system accuracy along radial 4.5°, 95 percent of occasions, is a realistic, conservative figure. Thus, in normal use of VOR or TACAN intersections, fix displacement factors may conservatively be assessed as follows:

a. Along-Course Accuracy.

(1) VOR/TACAN radials, plus-or-minus 4.5°.

(2) Localizer course, plus-or-minus 1°.

(3) NDB courses or bearing, plus-or-minus 5°.

NOTE: The plus-or-minus 4.5° (95 percent) VOR/TACAN figure is achieved when the ground station course signal error, the FTE, and the VOR airborne equipment error are controlled to certain normal tolerances. Where it can be shown that any of the three error elements is consistently different from these assumptions (for example, if flight inspection shows a consistently better VOR signal accuracy or stability than the one assumed, or if it can be shown that airborne equipment error is consistently smaller than assumed), VOR fix displacement factors smaller than those shown above may be utilized under paragraph 141.

b. Crossing Course Accuracy.

(1) VOR/TACAN radials, plus-or-minus 3.6°.

(2) Localizer course, plus-or-minus 0.5°.

(3) NDB bearings, plus-or-minus 5°.

NOTE: The plus-or-minus 3.6° (95 percent) VOR/TACAN figure is achieved when the ground station course signal error and the VOR airborne equipment error are controlled to certain normal tolerances. Since the crossing course is not flown, FTE is not a contributing element. Where it can be shown that either of the error elements is consistently different, VOR displacement factors smaller than those shown above may be utilized IAW paragraph 141.

286. OTHER FIX DISPLACEMENT FACTORS.

a. Radar. Plus-or-minus 500 feet or 3 percent of the distance to the antenna, whichever is greater.

b. DME. Plus-or-minus 1/2 (0.5) miles or 3 percent of the distance to the antenna, whichever is greater.

c. 75 MHz Marker Beacon.

(1) Normal powered fan marker, plus-or-minus 2 miles.

(2) Bone-shaped fan marker, plus-or-minus 1 mile.

(3) Low powered fan marker, plus-or-minus 1/2 mile.

(4) "Z" marker, plus-or-minus 1/2 mile.

NOTE: Where these 75 MHz marker values are restrictive, the actual coverage of the fan marker (2 milliamp signal level) at the specific location and altitude may be used instead.

d. Overheading a Station. The fix error involved in station passage is not considered significant in terminal applications. The fix is therefore considered to be at the plotted position of the navigation facility. The use of TACAN station passage as a fix is **NOT** acceptable for holding fixes or high altitude IAF's.

287. SATISFACTORY FIXES.

a. Intermediate, Initial, or Feeder Fix. To be satisfactory as an intermediate, initial, or feeder approach fix, the fix error must not be larger than 50 percent of the appropriate segment distance that follows the fix. Measurements are made from the plotted fix position (see figure 29).

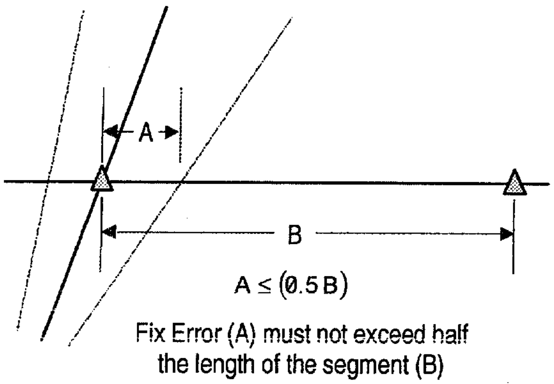


Figure 29. INTERMEDIATE, INITIAL, OR FEEDER APPROACH FIX ERRORS. Par 287.

b. Holding Fixes. Any terminal area fix except overheading a TACAN may be used for holding. The following conditions shall exist when the fix is an intersection formed by courses or radials:

(1) The angle of divergence of the intersecting courses or radials shall not be less than 45°.

(2) If the facility which provides the crossing courses is NOT an NDB, it may be as much as 45 miles from the point of intersection.

(3) If the facility which provides the crossing course is an NDB, it must be within 30 miles of the intersection point.

(4) If distances stated in paragraphs 287b(2) or (3) are exceeded, the minimum angle of divergence of the intersecting courses must be increased at the following rate:

(a) If an NDB facility is involved, 1° for each mile over 30 miles.

(b) If an NDB facility is NOT involved, 1/2° for each mile over 45 miles.

FIGURE 30 DELETED BY CHG 19.

c. FAF. For a fix to be satisfactory for use as a FAF, the fix error should not exceed plus-or-minus 1 mile (see figures 31-1 and 31-2). It may be as large as plus-or-minus 2 miles when:

(1) The MAP is marked by overheading an air navigation facility (except 75 MHz markers); OR

(2) A buffer of equal length to the excessive fix error is provided between the published MAP and the point where the missed approach surface begins (see figure 32).

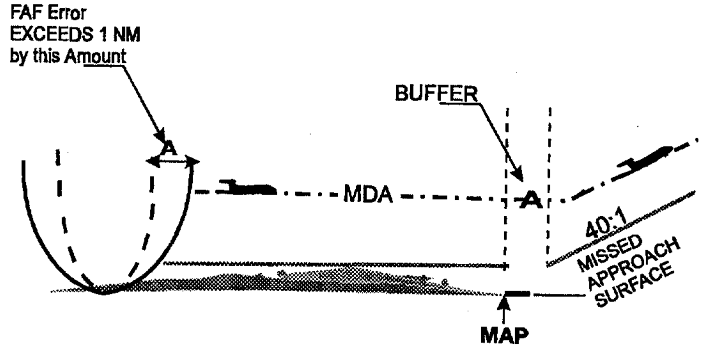


Figure 32. FAF ERROR BUFFER. Par 287c(2).

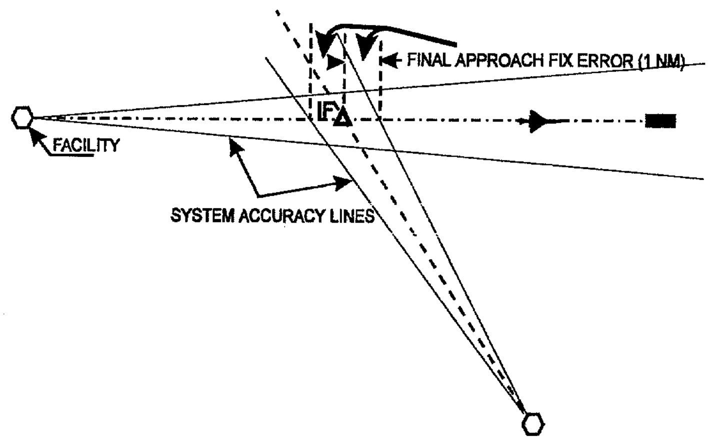
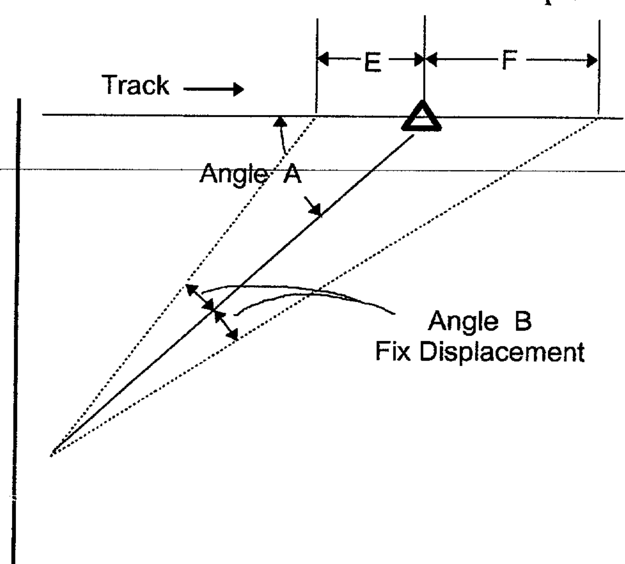


Figure 31-1. MEASUREMENT OF FAF ERROR. Par 287c.

Calculate fix displacement using the following formulas:



Formula	*Example*
$E = \dfrac{6076.11548 \times D \times \text{Sin } B}{\text{Sin }(A + B)}$	$E = \dfrac{6076.11548 \times 30 \times \text{Sin } 3.6^\circ}{\text{Sin }(50 + 3.6^\circ)}$
	$E = 14220.10$
$F = \dfrac{6076.11548 \times D \times \text{Sin } B}{\text{Sin }(A - B)}$	$F = \dfrac{6076.11548 \times 30 \times \text{Sin } 3.6^\circ}{\text{Sin }(50^\circ - 3.6^\circ)}$
	$F = 15805.19$

Figure 31-2. FIX DISPLACEMENT CALCULATIONS. Par 287c.

between the step-down fix and the MAP, provided the fix is within 6 miles of the landing surface. These criteria are applicable to nonprecision approach procedures only.

324. DECISION ALTITUDE (DA). The DA applies to approach procedures where the pilot is provided with glidepath deviation information; e.g., ILS, MLS, TLS, GLS, LNAV/VNAV, Baro VNAV, or PAR. The DA is the barometric altitude, specified in feet above MSL, at which a missed approach shall be initiated if the required visual reference has not been established. DA's shall be established with respect to the approach obstacle clearance and HAT requirements specified in TERPS Volume 3.

325. DECISION HEIGHT (DH). The DH is the value of the DA expressed in feet above the highest runway elevation in the touchdown zone. This value is also referred to as **HAT**.

326.-329. RESERVED.

Section 3. Visibilities.

330. ESTABLISHMENT OF VISIBILITY MINIMUMS.

a. Straight-in minimums for NONPRECISION approaches shall be established for an approach category when:

(1) The final approach course-runway alignment criteria have been met, AND

(2) The visibility requirements of paragraph 331 are met, AND

(3) The height of the MDA above touchdown zone elevation (TDZE) and the associated visibility are within the tolerances specified in paragraph 331, AND

(4) The descent gradient from the final approach fix to the runway does not exceed the maximum specified in the applicable facility chapter of this order.

b. Straight-in minimums for PRECISION approaches shall be established for an approach category when the final approach course alignment criteria have been met.

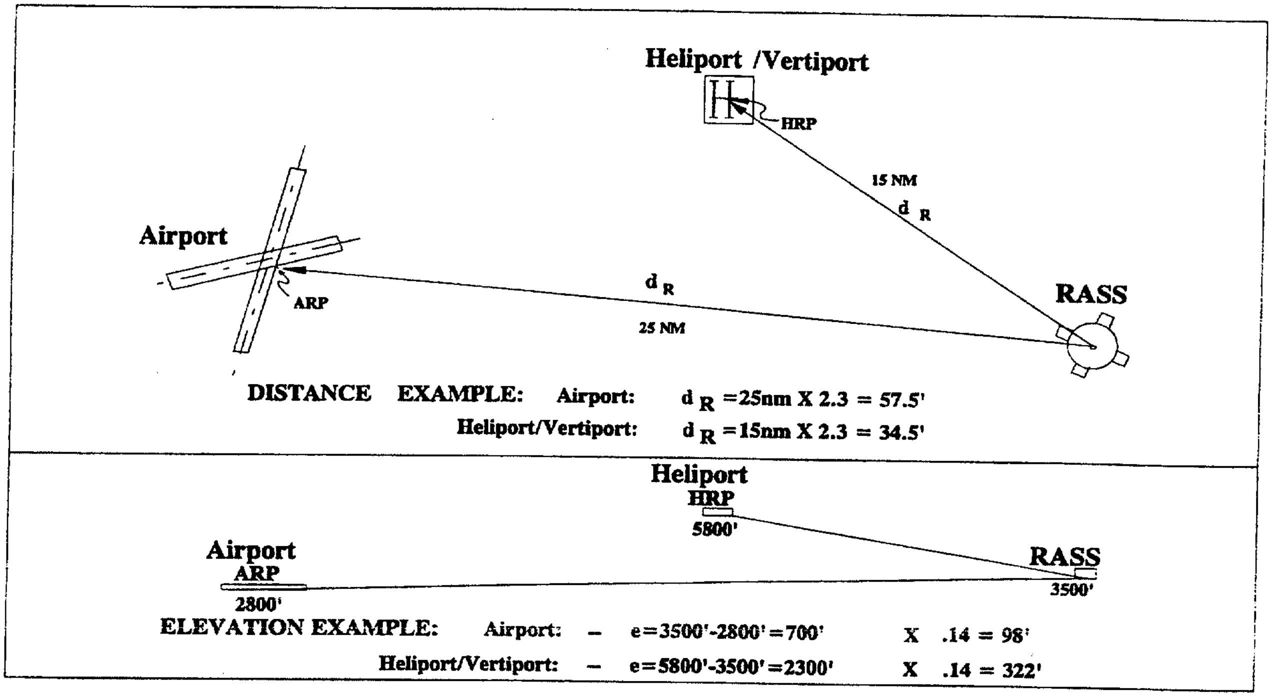
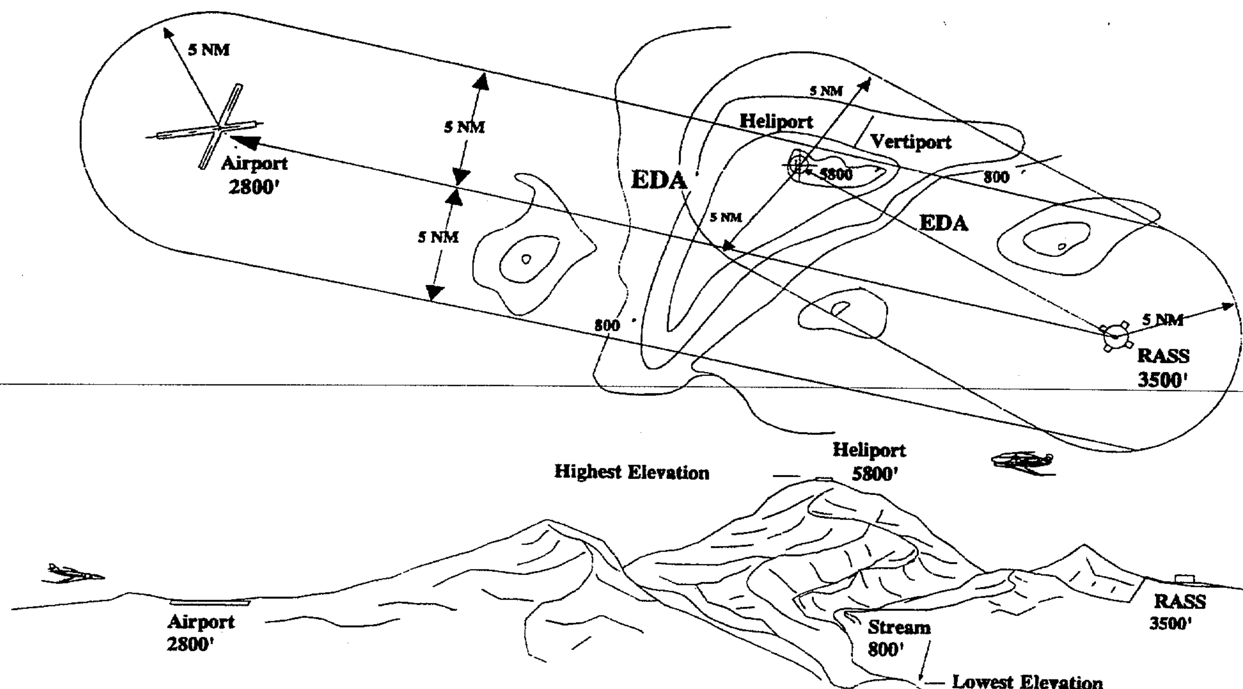


Figure 37B. DISTANCE REMOTED (d_R) AND ELEVATION. Par 323b.



EXAMPLE: ELEVATION DIFFERENTIAL: Airport: – E=5800'-800'=5000' X .14 = 700'
Heliport/Vertiport: – E=5800'-800'=5000' X .14 = 700'

Figure 37C. ELEVATION DIFFERENTIAL AREA (EDA). Par. 323b. WHERE INTERVENING TERRAIN INFLUENCES ATMOSPHERIC PRESSURE PATTERNS.

Table 8. STANDARD LIGHTING SYSTEMS

ABBREV. IFR	LIGHTING SYSTEM	Operating. Coverage (Degrees) Lateral (±)	Vertical (above Horizon.)
ALSF-I	Standard approach light system with sequenced flashers	21.0* 12.5#	12.0* 12.5#
ALSF-II	Standard approach light system with sequenced flashers & CAT II mod.	21.0* 12.5#	12.0* 12.5#
SSALS	Simplified short approach light system	21.0	12.0
SSALF	Simplified short approach light system with sequenced flashers	21.0* 12.5#	12.0* 12.5#
SSALR	Simplified short approach light system with runway alignment indicator lights	21.0* 12.5#	12.0* 12.5#
MALS	Medium intensity approach light system	10.0	10.0*
MALSF	Medium intensity approach light system with sequenced flashers	10.0* 12.5#	10.0* 12.5#
MALSR	Medium intensity approach light system with runway alignment indicator lights	10.0* 12.5#	10.0* 12.5#
ODALS	Omnidirectional approach light system	360#	+2- +10#
VFR			
REIL	Runway end identifier lights	12.5	12.5
LDIN	Lead-in lighting system (can be * or #)	12.5	12.5
VASI	Visual approach slope indicators	10.0	3.5

RUNWAY LIGHT SYSTEMS

HIRL	High intensity runway lights
MIRL	Medium intensity runway lights
LIRL	Low intensity runway lights
TDZ/CL	Touchdown zone and centerline lights

NOTE: Descriptions of lighting systems may be found in appendix 5 and FAA Order 6850.2.

**Steady-burning* *#Sequenced flashers*

343. VISIBILITY REDUCTION. Standard visibility requirements are computed by applying the criteria contained in paragraph 331. When the visibility without lights value does not exceed 3 statute miles, these requirements may be reduced by giving credit for standard or equivalent approach light system as follows (see paragraph 341 and appendix 5):

a. **The provisions of paragraphs** 251, 332, 342, or 1025 must be met.

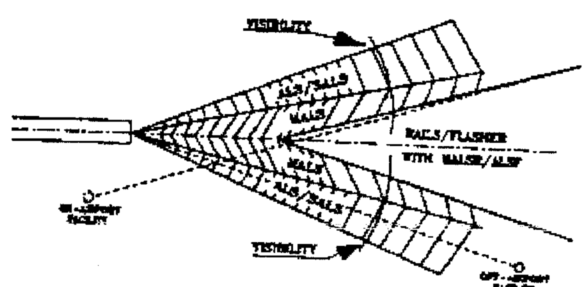


Figure 37D. APPLICATION OF LATERAL COVERAGE ANGLES OF TABLE 8, Par 42b.

NOTE: The final approach course to an 'on airport' facility transits all approach light operational areas within the limits of visibility arc, whereas the final approach course from the 'off-airport' facility may be restricted only to an ALS or SALS for visibility credit.

b. Where the visibility required without lights does not exceed one mile, visibility as low as that specified in the appropriate table in paragraph 350 with associated DH or HAT and lighting may be authorized.

c. For civil application, where the visibility required without lights exceeds 1 mile, a reduction of ½ mile may be made for SSALR, MALSR or ALSF-1/2 provided such visibility minimum is not less than that specified in paragraph 350. Reduction for CAT D aircraft in NDB approach procedures shall not exceed 1/4 mile or result in visibility minimums lower than 1 mile.

d. For military applications, where the visibility required without lights exceeds 1 mile, a reduction of 1/4 mile may be made for SSALS, SALS, MALS, or ODALS, and a reduction of 1/2 mile may be made for ALS, SSALR, or MALSR provided such visibility minimum is not less than that specified in paragraph 350.

e. Where visibility minimums are established in order to see and avoid obstacles, visibility reductions shall not be authorized.

f. Visibility reductions are NOT cumulative.

344. OTHER LIGHTING SYSTEMS. In order for variations of standard systems and other systems not included in this chapter to receive visibility reduction credit, the operational conditions specified in paragraph 342 must be met. Civil airport lighting systems which do not meet known standards or for which criteria do not exist, will be handled UNDER the provisions of paragraph 141. Military lighting systems may be equated to standard systems for reduction of visibility as illustrated in appendix 5. Where existing systems vary from the configurations illustrated there and cannot be equated to a standard system, they shall be referred to the appropriate approving authority for special consideration.

345.-349. RESERVED.

SECTION 5. STANDARD MINIMUMS

350. STANDARD STRAIGHT-IN MINIMUMS. Table 9 specifies the lowest NONPRECISION and Volume 3, table 2-2B specifies the lowest PRECISION civil minimums that may be prescribed for various combinations of electronic and visual navigation aids. Table 10 specifies the lowest DOD NONPRECISION and PRECISION minimums. Lower minimums based on special equipment or aircrew qualifications may be authorized only by approving authorities. Higher minimums shall be specified where required by application of criteria contained elsewhere in this order.

351. STANDARD CIRCLING MINIMUMS. Table 11 specifies the lowest civil and military minimums that may be prescribed for circling approaches. See also paragraph 330c. The MDA established by application of the minimums specified in this paragraph shall be rounded to the next higher 20 feet.

352.-359. RESERVED.

SECTION 6. ALTERNATE MINIMUMS

360. STANDARD ALTERNATE MINIMUMS. Minimums authorized when an airport is to be used as an alternate airport appear in table 12. The ceiling and visibility specified shall NOT be lower than the circling HAA and visibility, or as specified in military directives for military operations.

361.-369. RESERVED.

SECTION 7. DEPARTURES

370. STANDARD TAKEOFF MINIMUMS. Where applicable, civil standard takeoff minimums are specified by the number of engines on the aircraft. Takeoff minimums are stated as visibility only, except where the need to see and avoid an obstacle makes a ceiling value necessary (see table 13). In this case the published procedure shall identify the location of the controlling obstacle. Takeoff minimums for military operations shall be as stated in the appropriate service directives.

Table 9. STANDARD STRAIGHT-IN MINIMUMS

	NONPRECISION APPROACHES Procedures associated with 14 CFR Part 97.23, 25, 27, 31, 33, and 35					
	APPROACH LIGHT CONFIGURATION	CAT →	A — B — C		D	
		HAT[1]	Vis	or RVR	Vis	or RVR
1	NO LIGHTS	250	1	5000	1	5000
2	ODALS	250	3/4	4000	1	5000
3	MALS	250	3/4	4000	1	5000
4	SSALS/SALS	250	3/4	4000	1	5000
5	MALSR	250	1/2[2]	2400	1[3]	5000
6	SSALR	250	1/2[2]	2400	1[3]	5000
7	ALSF-1	250	1/2[2]	2400	1[3]	5000
8	DME Arc Any Light Configuration	500	1	5000	1	5000

[1] Add 50 ft to HAT for VOR without FAF or NDB with FAF.
Add 100 ft to HAT for NDB without FAF.
[2] For NDB approaches, 3/4 mile or RVR 4000.
[3] For LOC and LNAV/VNAV, 3/4 miles or RVR 4000.

	PRECISION APPROACHES 14 CFR Part 97.29					
	APPROACH LIGHT CONFIGURATION	CAT →	A — B — C		D	
		HAT[4]	Vis	or RVR	Vis	or RVR
9	NO LIGHTS	200	3/4	4000	3/4	4000
~~10~~	~~MALSR~~	~~200~~	~~1/2~~	~~2400~~	~~1/2~~	~~2400~~
11	SSALR	200	1/2	2400	1/2	2400
12	ALSF-1	200	1/2	2400	1/2	2400
13	ALSF-1-TDZ/CL MALSR-TDZ/CL SSALR-TDZ/CL	200	-	1800	-	1800

[4] ILS includes LOC, GS, and OM (or FAF). For an Offset LOC, the minimum HAT is 250 and minimum RVR is 2400.

NOTE: HIRL is required for RVR. Runway edge lights required for night.

Table 10. MILITARY STANDARD STRAIGHT-IN MINIMUMS

		NO LIGHTS		ALS TDZ/CL		ALS		SSALR		SALS or SSALS		MALSR		MALS		ODALS	
PRECISION																	
HAT	CAT	MILE	RVR[1]	MILE	RVR	MILE	RVR	MILE	RVR	MILE	RVR	MILE	RVR	MILE	RVR	MILE	RVR
100	A–E	1/2	24	—	12	1/4	18	1/4	16	1/4	16	1/2	24	1/2	24	1/2	24
200	A–B	3/4	40	1/2	18	1/2	24	1/2[2]	24[2]	1/2	24	1/2	24	3/4	40	1/2	24
200	C.D.E..	3/4	40	1/2[2]	24[2]	1/2[2]	24[2]	1/2[2]	24[2]	3/4	40	1/2[2]	24[2]	3/4	40	3/4	40
250	A–B	3/4[4]	40[4]	1/2	24	1/2[3]	24[3]	1/2	24	3/4	40	1/2	24	3/4	40	3/4	40
250	C.D.E	1	50	1/2	24	1/2[3]	24[3]	1/2	24	3/4	40	1/2	24	3/4	40	1	50
NONPRECISION																	
AS REQUIRED	A-B	1	50	1/2	24	1/2	24	1/2	24	3/4	40	1/2	24	3/4	40	3/4	40
AS REQUIRED	C.D.E	1	50	3/4	40	3/4	40	3/4	40	3/4	40	3/4	40	3/4	40	3/4	40
DME ARC APPROACH																	
AS REQUIRED	A–E	1	50	(REDUCTION BELOW ONE MILE NOT AUTHORIZED)													

[1]RVR shown in hundreds of feet, i.e., RVR 24=2,400 feet.
[2]Minimum length of approach lights is 2,000 feet.
[3]For non-standard ALS lengths of:
  a. 2,400 to 2,900 feet, use SSALR.
  b. 1,000 to 2,300 feet, use SSALS.
[4]When the MAP is located 3/4 statute mile or less from the threshold.

INSTRUCTIONS FOR ESTABLISHING MILITARY STRAIGHT-IN MINIMUMS (Use Table 10)

STEP 1.	Determine the required DH or MDA by applying criteria found in the appropriate facility chapter of this Order.
STEP 2.	Determine the height above touchdown (HAT) zone elevation.
STEP 3.	Determine the visibility value as follows: a. Precision Approaches. (1) HAT 250 feet or less. Enter "precision" portion of table 10 at HAT value for aircraft approach category. Read across table to determine minimum visibility for the appropriate light system. If the HAT is not shown on the table, use the next higher HAT. (2) HAT greater than 250 feet. Use the instructions for the nonprecision minimums in paragraph b below. Paragraph 331 does not apply. b. Nonprecision Approaches. Determine the basic visibility by application of criteria in paragraphs 330 and 331. If the basic visibility is 1 mile, enter table 10 with aircraft approach category being considered. Read across the table to determine minimum visibility for the appropriate light system.
STEP 4.	Establish ceiling values in 100-foot increments in accordance with paragraph 310.

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CHAPTER 8. VHF/UHF DF PROCEDURES

800. GENERAL. These criteria apply to direction finder (DF) procedures for both high and low altitude aircraft. DF criteria shall be the same as criteria provided for automatic direction finder (ADF) procedures, except as specified herein. As used in this chapter, the word "facility" means the DF antenna site. DF approach procedures are established for use in emergency situations. However, where required by a using agency, DF may be used for normal instrument approach procedures.

801.-809. RESERVED.

Section 1. VHF/UHF DF Criteria

810. EN ROUTE OPERATIONS. En route aircraft under DF control follow a course to the DF station as determined by the DF controller. A minimum safe altitude shall be established which provides at least 1,000 feet (2,000 feet in mountainous areas) of clearance over all obstacles within the operational radius of the DF facility. When this altitude proves unduly restrictive, sector altitudes may be established to provide relief from obstacles, which are clear of the area where flight is conducted. Where sector altitudes are established, they shall be limited to sectors of not less than 45 degrees in areas BEYOND a 10-mile radius around the facility. For areas WITHIN 10 miles of the facility, sectors of NOT LESS THAN 90 degrees shall be used. Because the flight course may coincide with the sector division line, the sector altitude shall provide at least 1,000 feet (2,000 feet in mountainous terrain) of clearance over obstacles in the adjacent sectors within 6 miles or 20 degrees of the sector division line, whichever is the greater. No sector altitude shall be specified which is lower than the procedure or penetration turn altitude or lower than the altitude for area sectors, which are closer to the navigation facility.

811. INITIAL APPROACH SEGMENT. The initial approach fix is overhead the facility.

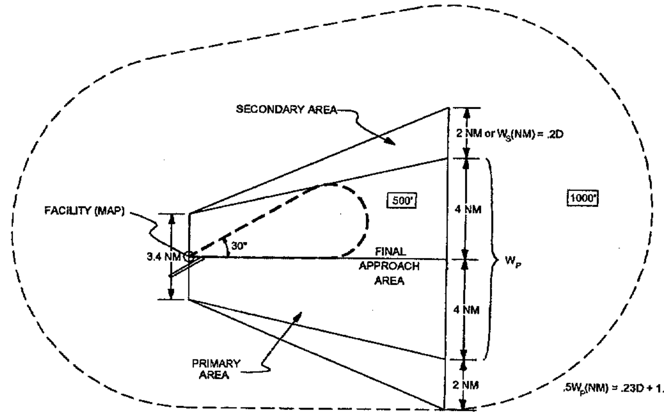


Figure 72. LOW ALTITUDE DF APPROACH AREA, Par 811.

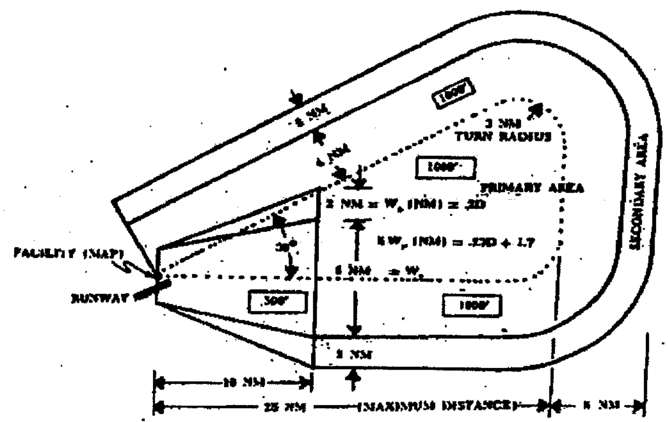


Figure 73, HIGH ALTITUDE DF APPROACH AREA, Par 811.

a. Low Altitude Procedures. The initial approach may be either a 10-mile teardrop procedure turn or the triangular procedure illustrated in figure 72. In either case, the 10-mile procedure turn criteria contained in paragraphs 234a, b, c, and d apply.

b. High Altitude Procedures. The initial approach may be either the standard teardrop penetration turn or the triangular procedure illustrated in figure 73. When the teardrop penetration turn is used, the criteria contained in paragraphs 235a, b, c, and d apply. When the triangular procedure is used, the same criteria apply except that the limiting angular divergence between the outbound course and the reciprocal of the inbound course may be as much as 45 degrees.

812. INTERMEDIATE APPROACH SEGMENT. Except as outlined in this paragraph, criteria for the intermediate segment are contained in chapter 2, section 4. An intermediate segment is used only when the DF facility is located off the airport and the final approach is made from overhead the facility to the airport. The width of the primary intermediate area is 3.4 miles at the facility, expanding uniformly on each side of the course to 8 miles wide 10 miles from the facility. A secondary area is on each side of the primary area. It is zero miles wide at the facility, expanding along the primary area to 2 miles each side at 10 miles from the facility. See figure 74.

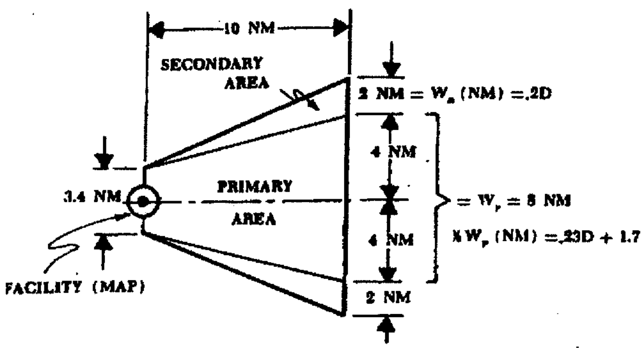


Figure 74. DF INTERMEDIATE APPROACH AREA. Par 812.

813. FINAL APPROACH SEGMENT. The final approach begins at the facility for off-airport facilities or where the procedure turn intersects the final approach course for on-airport facilities (see paragraph 400 for the definition of on-airport facilities). DF procedures shall not be developed for airports that are more than 10 miles from the DF facility. When a facility is located in excess of 6 miles from an airport, the instrument approach shall end at the facility and flight to the airport shall be conducted in accordance with visual flight rules (VFR).

a. Alignment.

(1) On - Airport Facilities. Paragraphs 613a(1) and (2) apply.

(1) Off - Airport Facilities. Paragraphs 713a(1)(a) and (b) apply.

b. Area.

(1) Low Altitude Procedures. Figure 74 illustrates the final approach primary and secondary areas. The primary area is longitudinally centered on the final approach course and is 10 miles long. The primary area is 3.4 miles wide at the facility and expands uniformly to 8 miles wide at 10 miles from the facility. A secondary area is on each side of the primary area. It is zero miles wide at the facility and expands uniformly to 2 miles on each side of the primary area at 10 miles from the facility.

(2) High Altitude Procedures. The area considered is identical to that described in paragraph 623b and figure 60 except that the primary area is 3.4 miles wide at the facility.

c. Obstacle Clearance.

(1) Straight-In. The minimum obstacle clearance in the primary area is 500 feet. In the secondary areas, 500 feet of obstacle clearance shall be provided at the inner edge, tapering to zero feet at the outer edge. The minimum required obstacle clearance at any given point in the secondary area can be computed by using the formula specified in paragraph 523b.

(2) Circling Approach. In addition to the minimum requirements specified in paragraph 813c(1), obstacle clearance in the circling area shall be as prescribed in chapter 2, section 6.

d. Procedure Turn Altitude. The procedure turn completion altitude (minimum base leg altitude in triangular procedures) shall be within 1,500 feet of the MDA on final approach.

e. Penetration Turn Altitude (Descent Gradient). The penetration turn altitude (minimum base leg altitude in triangular procedures) shall be at least 1,000 feet but not more than 4,000 feet above the MDA on final approach.

f. Minimum Descent Altitude (MDA). The criteria for determining MDA are contained in chapter 3, section 2, except that in high altitude procedures, the MDA specified shall provide at least 1,000 feet of clearance over obstacles in that portion of the initial approach segment between the final approach segment and the point where the assumed penetration course intercepts the inbound course (see figure 60).

814. MISSED APPROACH SEGMENT. Criteria for the missed approach segment are contained in chapter 2, section 7. For on-airport facility locations, the missed approach point is the facility. For off-airport facility locations, the missed approach point is a point on the final approach course which is NOT farther from the facility than the first usable landing surface. The missed approach surface shall commence over the missed approach point at the required height (see paragraph 274).

815.-819. RESERVED.

Section 2. Communications.

820. TRANSMISSION INTERVAL. DF navigation is based on voice transmission of heading and altitude instructions by a ground station to the aircraft. The MAXIMUM interval between transmissions is:

a. En route Operations. 60 seconds.

b. From the Initial Approach Fix to Within an Estimated 30 Seconds of the Final Station Passage or Missed Approach Point. 15 seconds

c. **Within 30 Seconds of the Final Station Passage or Missed Approach Point.** 5 seconds. (15 seconds for doppler DF equipment).

821.-829. RESERVED.

Section 3. Minimums.

830. APPROACH MINIMUMS. The minimums established for a particular airport shall be as prescribed by the appropriate approving agency, but the MDA shall NOT be lower than that required for obstacle clearance on final approach and in the circling area specified in chapter 2, section 6.

831.-899. RESERVED.

CHAPTER 9. LOCALIZER AND LOCALIZER TYPE DIRECTIONAL AIDS (LDA)

900. FEEDER ROUTES, INTIAL APPROACH, AND INTERMEDIATE SEGMENTS. These criteria are contained in chapter 2, Section 3. When associated with a precision approach procedure, Volume 3, paragraph 2.3 applies.

901. USE OF LOCALIZER ONLY. Where no usable glidepath is available, a localizer-only (front or back course) approach may be approved, provided the approach is made on a LOC from a FAF located within 10 miles of the runway threshold. Criteria in this section are also applicable to procedures based on localizer type directional aids (LDA). Back course procedures shall not be based on courses that exceed 6° in width and shall not be approved for offset LOC.

902. ALIGNMENT. Localizers which are aligned within 3° of the runway alignment shall be identified as localizers. If the alignment exceeds 3°, they will be identified as LDA facilities. The alignment of the course for LDA facilities shall meet the final approach alignment criteria for VOR on-airport facilities. See chapter 5, paragraph 513, and figure 48.

903. AREA. The final approach dimensions are specified in figure 75. However, only that portion of the final approach area that is between the FAF and the runway need be considered as the final approach segment for obstacle clearance purposes. The optimum length of the final approach segment is 5 miles. The MINIMUM length of the final approach segment shall be sufficient to provide adequate distance for an aircraft to make the required descent. The area shall be centered on the FAC and shall commence at the runway threshold. For LDA procedures, the final approach area shall commence at the facility and extend to the FAF. The MAP for LDA procedures shall not be farther from the FAF than a point adjacent to the landing threshold perpendicular to the FAC. Calculate the width of the area using the following formulae:

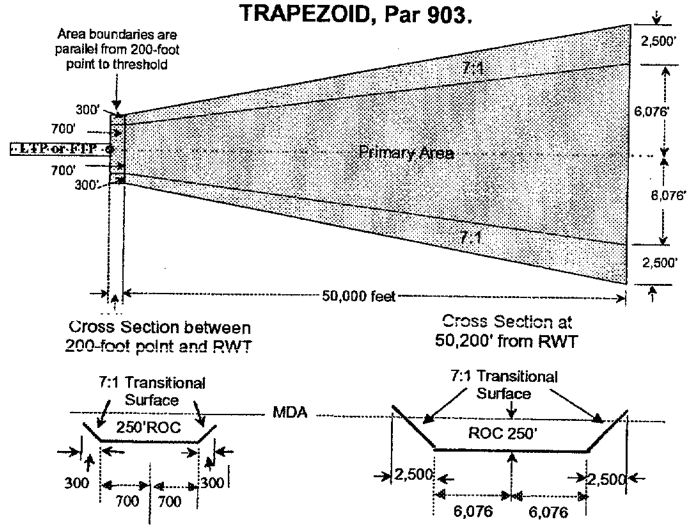
Perpendicular Width from RCL to the Edge of the Primary = $0.10752(D-200)+700$

Perpendicular Width from RCL to the Edge of the Transitional Sfc = $0.15152(D-200)+1000$

Where D = Distance (ft) from RWT measured along RCL

904. OBSTACLE CLEARANCE. The minimum ROC in the final approach area is 250 feet. In addition, the MDA established for the final approach area shall assure that no obstacles penetrate the 7:1 transitional surfaces.

Figure 75. LOCALIZER FINAL TRAPEZOID, Par 903.



905. DESCENT GRADIENT. The OPTIMUM gradient in the final approach segment is 318 feet per mile. Where a higher descent gradient is necessary, the MAXIMUM permissible gradient is 400 feet per mile. When maximum straight-in descent gradient is exceeded, then a "circling only" procedure is authorized. When a stepdown fix is incorporated, descent gradient criteria must be met from FAF to SDF and SDF to FEP. See para-graphs 251, 252, and 288a.

906. MDA. The lowest altitude on final approach is specified as an MDA. The MDA adjustments specified in paragraph 232 shall be considered.

907. MISSED APPROACH SEGMENT. The criteria for the missed approach segment are contained in chapter 2, section 7. The MAP is on the FAC not farther from the FAF than the runway threshold (first usable portion of the landing area for circling approach). The missed approach surface shall commence over the MAP at the required height (see paragraph 274).

908.-909. RESERVED

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CHAPTER 11. HELICOPTER PROCEDURES

Section 1. Administrative

1100. GENERAL. This chapter contains criteria for application to "helicopter only" procedures. These criteria are based on the premise that helicopters are classified in approach Category A and are capable of special maneuvering characteristics. The intent, therefore, is to provide relief from those portions of other TERPS chapters that are more restrictive than the criteria specified herein. However, any criteria contained elsewhere in other chapters of this document may be applied to helicopter only procedures when an operational advantage may be gained.

a. Identification of Inapplicable Criteria. Criteria contained elsewhere in this document normally apply to helicopter procedures. Where this chapter changes such criteria, the changed material is identified. Circling approach and high altitude penetration criteria do not apply to helicopter procedures.

b. Use of Existing Facilities. Helicopter only procedures based on existing facilities may be developed using criteria contained in this chapter.

1101. TERMINOLOGY. The following terms are peculiar to helicopter procedures and are defined as follows:

a. Height Above Landing (HAL) is the height above landing area elevation.

b. Height Above the Surface (HAS) is the height of the MDA above the highest terrain/surface within a 5,200-foot radius of the MAP in point in space procedures.

c. Landing Area as used in helicopter operations refers to the portion of the heliport or airport runway used, or intended to be used for the landing and takeoff of helicopters.

d. Landing Area Boundary (LAB) is the beginning of the landing area of the heliport or runway.

e. Point in Space Approach is an instrument approach procedure to a point in space, identified as a missed approach point, which is not associated with a specific landing area within 2,600 feet of the MAP.

f. Touchdown zone, as used in helicopter procedures, is identical to the landing area.

1102. DELETED.

1103. TYPE OF PROCEDURE. HELICOPTER ONLY PROCEDURES are designed to meet low altitude straight-in requirements ONLY.

1104. FACILITIES FOR WHICH CRITERIA ARE NOT PROVIDED. This chapter does not include criteria for procedures predicated on VHF/UHF DF, area navigation (RNAV), airborne radar approach (ARA), or microwave landing system (MLS). Procedures using VHF/UHF DF may be developed in accordance with the appropriate chapters of this document.

1105. PROCEDURE IDENTIFICATION. Identify helicopter-only procedures using the term "COPTER," the type of facility or system providing final approach course guidance, and:

a. For Approaches to Runways. The abbreviation RWY, and the runway number; e.g., COPTER ILS or LOC RWY 17; COPTER RNAV (GPS) RWY 31.

b. For Approaches to Heliports and a Point-in-Space. The magnetic final approach course value and degree symbol; e.g., COPTER ILS or LOC 014°; COPTER TACAN O97°, COPTER RNAV (GPS) 010°.

c. For Approaches Based on an ARC Final. The word ARC will be used, and will be followed by a sequential number; e.g., COPTER VOR/DME ARC 1.

d. For separate procedures at the same location. Use the same type of facility and same final approach course, add an alpha suffix starting in reverse alphabetical order; COPTER ILS or LOC Z RWY 28L (first procedure), COPTER ILS or LOC Y RWY 28L (second procedure), COPTER ILS or LOC X RWY 28L (third procedure), etc.

Section 2. General Criteria

1106. APPLICATION. These criteria are based on the unique maneuvering capability of the helicopter at airspeeds not exceeding 90 knots.

1107. POINT IN SPACE APPROACH. Where the center of the landing area is not within 2,600 feet of the MAP, an approach procedure to a point in space may be developed using any of the facilities for which criteria are provided in this chapter. In such procedures the point in space and the missed approach point are identical and upon arrival at this point, helicopters must proceed under visual flight rules (or special VFR in control zone as applicable) to a landing area or conduct the specified missed approach procedure. The published procedure shall be noted to this effect and also should identify available landing areas in the vicinity by noting the course and distance from the MAP to each selected landing area. Point in space approach procedures will not contain alternate minima.

1108. APPROACH CATEGORIES. When helicopters use instrument flight procedures designed for fixed wing aircraft, approach Category "A" approach minima shall apply regardless of helicopter weight.

1109. PROCEDURE CONSTRUCTION. Paragraph 214 applies except for the reference to circling approach.

1110. DESCENT GRADIENT. The descent gradient criteria specified in other chapters of this document do not apply. The optimum descent gradient in *all* segments of helicopter approach procedures is 400 feet per mile. Where a higher descent gradient is necessary, the recommended maximum is 600 feet per mile. However, where an operational requirement exists, a gradient of as much as 800 feet per mile may be authorized, provided the gradient used is depicted on approach charts. See special procedure turn criteria in paragraph 1112.

1111. INITIAL APPROACH SEGMENTS BASED ON STRAIGHT COURSES AND ARCS WITH POSITIVE COURSE GUIDANCE. Paragraph 232 is changed as follows:

a. Alignment.

(1) Courses. The 2-mile lead radial specified in paragraph 232a(1) is reduced to 1 mile. See Figure 3.

(2) Arcs. The minimum arc radius specified in paragraph 232a(2) is reduced to 4 miles. The 2-mile lead radial may be reduced to 1 mile. See Figure 10.

1112. INITIAL APPROACH BASED ON PROCEDURE TURN. Paragraph 234 applies except for all of subparagraph d and the number 300 in subparagraph e(1) which is changed to 600. Since helicopters operate at approach Category A speeds the 5-mile procedure turn will normally be used. However, the larger 10-and 15-mile areas may be used if considered necessary.

a. Descent Gradient. Because the actual length of the track will vary with environmental conditions and pilot technique, it is not practical to specify a descent gradient solely in feet per mile for the procedure turn. Instead, the descent gradient is controlled by requiring the procedure turn completion altitude to be as close as possible to the final approach fix altitude. The difference between the procedure turn completion altitude and the altitude over the final approach fix shall not be greater than those shown in Table 23.

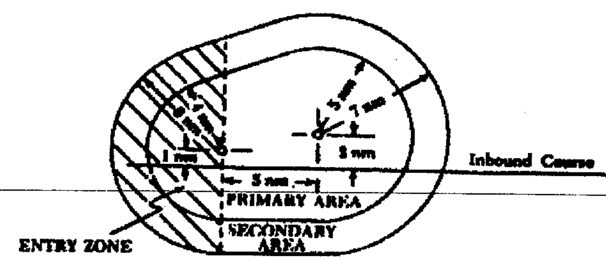

Figure 105. HELICOPTER PROCEDURE TURN AREA. Par 1112.

Table 23. PROCEDURE TURN COMPLETION ALTITUDE DIFFERENCE. Par 1112.

Type Procedure Turn	Altitude Difference
15 mile PT from FAF	Within 6000 ft of alt over FAF
10 mile PT from FAF	Within 4000 ft of alt over FAF
5 mile PT from FAF	Within 2000 ft of alt over FAF
15 mile PT, no FAF	Not Authorized
10 mile PT, no FAF	Within 4000 ft of MDA on Final
5 mile PT, no FAF	Within 2000 ft of MDA on Final

CHAPTER 14. SIMPLIFIED DIRECTIONAL FACILITIES (SDF) PROCEDURES

1400. GENERAL. This chapter applies to approach procedures based on Simplified Directional Facilities (SDF). "SDF" is a directional aid facility providing only lateral guidance (front or back course) for approach from a final approach fix.

1401.-1409. RESERVED.

1410. FEEDER ROUTES. Criteria for feeder routes are contained in paragraph 220.

1411. INITIAL APPROACH SEGMENT. Criteria for the initial approach segment are contained in chapter 2, section 3

1412. INTERMEDIATE APPROACH SEGMENT. Criteria for the intermediate approach segment are contained in chapter 2, section 4.

1413. FINAL APPROACH SEGMENT. The final approach shall be made only "TOWARD" the facility because of system characteristics. The final approach segment begins at the final approach fix and ends at the missed approach point.

a. Alignment. The alignment of the final approach course with the runway centerline determines whether a straight-in or circling-only approach may be established.

(1) Straight-in. The angle of convergence of the final approach course and the extended runway centerline shall not exceed 30°. The final approach course should be aligned to intersect the extended runway centerline 3,000 feet outward from the runway threshold. When an operational advantage can be achieved, this point of intersection may be established at any point between the threshold and a point 5,200 feet outward from the threshold. Also, where an operational advantage can be achieved, a final approach course which does not intersect the runway center, or which intersects it at a distance greater than 5,200 feet from the threshold may be established, provided that such a course lies within 500 feet laterally of the extended runway centerline at a point 3,000 feet outward from the runway threshold (see figure 48).

(2) Circling Approach. When the final approach course alignment does not meet the criteria for a straight-in landing, only a circling approach shall be authorized, and the course alignment should be made to the center of the landing area. When an operational advantage can be achieved, the final approach course may be aligned to any portion of the usable landing surface (see figure 49).

b. Area. The area considered for obstacle clearance in the final approach segment starts at the final approach fix (FAF) and ends at, or abeam, the runway threshold. It is a portion of a 10-mile long trapezoid that is centered longitudinally on the final approach course (see figure 14-1). For 6° course width facilities, it is 1,000 feet wide at, or abeam, the runway threshold and expands uniformly to 19,228 feet at 10 miles from the threshold. For 12° course width facilities, it is 2,800 feet wide at, or abeam, the runway threshold and expands uniformly to a width of 21,028 feet at 10 miles from the threshold. For course widths between 6° and 12°, the area considered for obstacle clearance may be extrapolated from the 6° and 12° figures to the next intermediate whole degree. For example, the width of the obstacle clearance area for a 9° course width would start at 1,900 feet and expand to 20,148 feet. The OPTIMUM length of the final approach segment is 5 miles. The MAXIMUM length is 10 miles. The MINIMUM length of the final approach segment shall provide adequate distance for an aircraft to make the required descent, and to regain course alignment when a turn is required over the facility. Table 14 shall be used to determine the minimum length needed to regain the course.

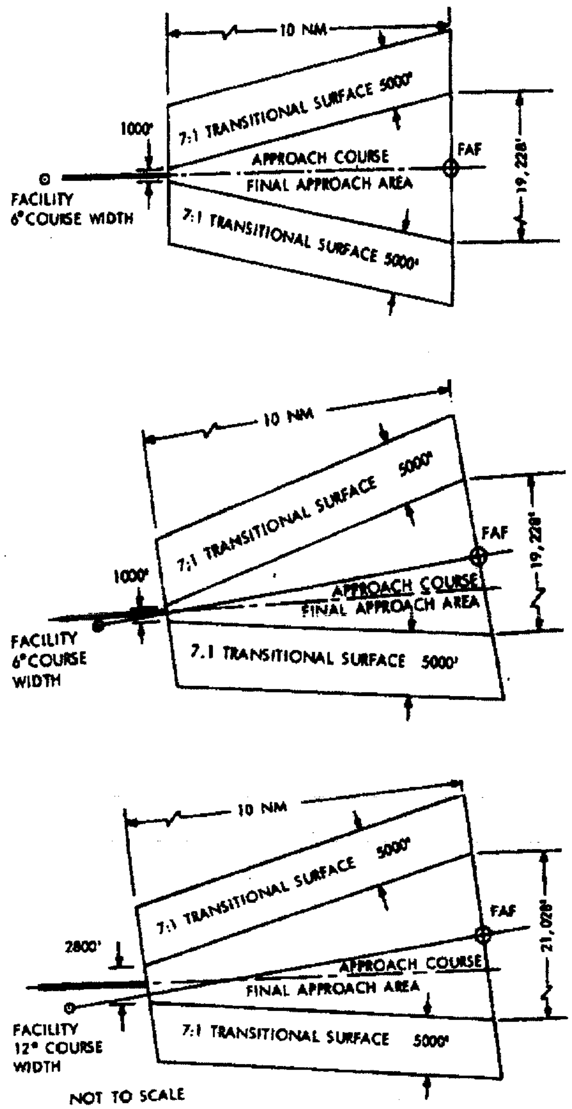

Figure 14-1. FINAL APPROACH AREAS WITH FAF.

c. Transitional Surfaces. Transitional surfaces are inclined planes with a slope of 7:1 that extend upward and outward 5,000 feet from the edge of the final approach area. The transitional surfaces begin at a height no less than 250 feet below the MDA.

d. Obstacle Clearance.

(1) Straight-in Landing. The minimum obstacle clearance in the final approach area shall be 250 feet. In addition, the MDA established for the final approach area shall assure that no obstacles penetrate the transitional surfaces.

(2) Circling Approach. In addition to the minimum requirements specified in paragraph 1413d(1), obstacle clearance in the circling area shall be as prescribed in chapter 2, section 6.

e. Descent Gradient. Criteria for descent gradient are specified in paragraph 252.

f. Use of Fixes. Criteria for the use of radio fixes are contained in chapter 2, section 8.

g. Minimum Descent Altitudes. Criteria for determining the MDA are contained in chapter 3, section 2.

1414. MISSED APPROACH SEGMENT. Criteria for the missed approach segment are contained in chapter 2, section 7. For SDF procedures the missed approach point is a point on the final approach course that is NOT farther from the final approach fix than the runway threshold (first usable portion of the landing area for circling). The missed approach surface shall commence over the missed approach point at the required height. See paragraph 274, missed approach obstacle clearance.

1415. BACK COURSE PROCEDURES. Back course SDF procedures may be developed using these criteria except that the beginning point of the final approach obstacle clearance trapezoid is at the facility.

1416.-1499. RESERVED.

b. When a change of altitudes is involved with a course change, course guidance must be provided if the change of altitude is more than 1,500 feet and/or if the course is more than 45 degrees.

EXCEPTION: Course changes of up to 90 degrees may be approved without course guidance provided that no obstacles penetrate the established MEA requirement of the previous airway/route segment within 15 NM of the boundaries of the system accuracy displacement area of the fix. See figure 17-22 and paragraph 1740b(2).

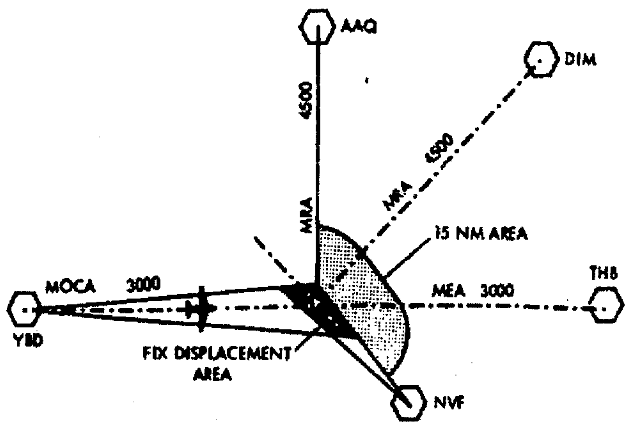

Figure 17-22. MEA WITH NAVIGATION GAP AT TURNING POINT. Par 1740b(2)

1731. EN ROUTE MINIMUM HOLDING ALTITUDES. Criteria for holding pattern airspace are contained in Order 7130.3, Holding Pattern Criteria, and provide for separation of aircraft from aircraft. The criteria contained in this document deal with the clearance of holding aircraft from obstacles.

a. Area. The primary obstacle clearance area for holding shall be based on the appropriate holding pattern airspace area specified in Order 7130.3. No reduction in the pattern sizes for "on entry" procedures is permitted. In addition, when holding at an intersection fix, the selected pattern shall also be large enough to contain at least 3 corners of the fix displacement area. See paragraphs 284, 285, and figure 37-1. A secondary area 2 miles wide surrounds the perimeter of the primary area.

b. Obstacle Clearance. The minimum obstacle clearance of the route shall be provided throughout the primary area. In the secondary area 500 feet of obstacle clearance shall be provided at the INNER edge, tapering to zero feet at the outer edge. For computation of obstacle clearance in the secondary area, the computation formula specified in paragraph 1721 shall be applied. Allowance for precipitous terrain should be considered as stated in paragraph 323a. The altitudes selected by application of the obstacle clearance specified in this paragraph may be rounded to the nearest 100 feet.

c. Communications. The communications on appropriate ATC frequencies (as determined by ATS) shall be required throughout the entire holding pattern area from the MHA up to and including the maximum holding altitude. If the communications are not satisfactory at the minimum holding obstacle clearance altitude, the MHA shall be authorized at an altitude where the communications are satisfactory. For communications to be satisfactory, they must meet the standards as set forth in Order 8200.1, United States Standard Flight Inspection Manual.

d. Holding Patterns On/Adjacent to ILS Courses. Holding patterns on or adjacent to ILS courses shall comply with Order 7130.3, paragraph 4-7.

e. High Altitude. All holding patterns in the high altitude structure shall be coordinated with the Aviation Systems Standards office prior to being approved.

1732.-1739. RESERVED.

Section 4. Navigational Gaps

1740. NAVIGATIONAL GAP CRITERIA. Where a gap in course guidance exists, an airway or route segment may be approved in accordance with the criteria set forth in paragraph 1740c, provided:

a. Restrictions.

(1) The gap may not exceed a distance which varies directly with altitude from zero NM at sea level to 65 NM at 45,000 feet MSL, and

(2) Not more than one gap may exist in the airspace structure for the airway/route segment, and

(3) A gap may not occur at any airway or route turning point, except when the provisions of paragraph 1740b(2) are applied, and

(4) A notation must be included on FAA Form 8260-16 which specifies the area within which a gap exists where the MEA has been established with a gap in navigational signal coverage. The gap area will be identified by distances from the navigation facilities.

b. Authorizations. MEA's with gaps shall be authorized only where a specific operational requirement exists. Where gaps exceed the distance in paragraph 1740a(1), or are in conflict with the limitations in paragraph 1740a(2) or (3), the MEA must be increased as follows:

(1) For straight segments:

(a) To an altitude which will meet the distance requirement of paragraph 1740a(1), or

(b) When in conflict with paragraph 1740a(1) or (2) to an altitude where there is continuous course guidance available.

(2) For turning segments. Turns to intercept radials with higher MEA's may be allowed provided:

(a) The increase in MEA does not exceed 1,500 feet, and

(b) The turn does not exceed 90 degrees, and

(c) No obstacles penetrate the MEA of the course being flown within 15 NM of the fix displacement area (see figure 17-22).

(3) When in conflict with paragraph 1740b(1) or (2) to an altitude where there is continuous course guidance available.

c. Use of Steps. Where large gaps exist which require the establishment of altitudes that obviate the effective use of airspace, consideration may be given to the establishment of MEA

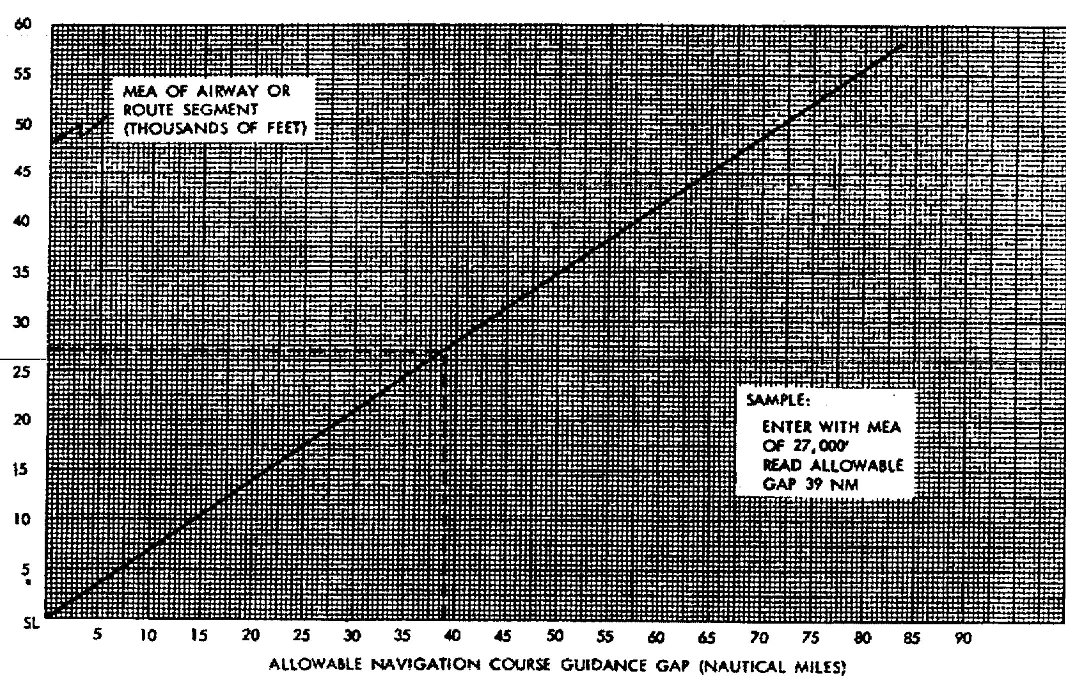

Figure 17-23. NAVIGATION COURSE GUIDANCE GAPS. Par 1740.

APPENDIX 1. APPENDIX APPLICATION, GLOSSARY, ACRONYMS, AND ABBREVIATIONS

1. APPENDIX APPLICATION. The material contained in these appendices supports criteria contained in several chapters of this order. Appendix material includes:

a. Appendix 1, paragraph 2. Glossary. A listing of special terms and abbreviations to explain their meaning and application to procedures and criteria.

b. Appendix 1, paragraph 3. Acronyms and Abbreviations. A listing of all acronyms and abbreviations used in this order.

c. Appendix 2. RESERVED

d. Appendix 3. References. This appendix contains a list of referenced publications.

e. Appendix 4. Table of Tangents. A complete list of tangents for angles from 0.0 to 9.0 degrees in hundredths of degrees for application in solving glide slope problems.

f. Appendix 5. Approach Lighting.Systems. This appendix contains descriptions of standard approach lighting systems and lists of other systems which may be given the same visibility credit in the development of military procedures.

g. Appendix 6. Alphabetical Index.

2. GLOSSARY. Definitions shown in the glossary apply to terminal instrument procedures criteria in this order.

AL Approach and Landing (Chart).

Angle of Divergence (Minimum). The smaller of the angles formed by the intersection of two courses, radials, bearings, or combinations thereof.

ASBL Approach Surface Baseline. An imaginary horizontal line at threshold elevation.

Approving Authority. Headquarters representative of the various signatory authorities shown in the Foreword, Page iv.

BC Back Course (Localizer).

Circling Approach Area. The area in which aircraft circle to land under visual conditions after completing an instrument landing approach.

Controlling Obstacle. The highest obstacle relative to a prescribed plane within a specified area.

NOTE: In precision approach procedures where obstacles penetrate the approach surface, the controlling obstacle is the one which results in the requirement for the highest decision height (DH).

Dead Reckoning. The estimating or determining of position by advancing an earlier known position by the application of direction and speed data. For example, flight based on a heading from one VORTAC azimuth and distance fix to another is dead reckoning.

Diverse Vector. An instruction issued by a radar controller to fly a specific course, which is not a part of a predetermined radar pattern. Also referred to as a "random vector."

DH Decision Height . The height, specified in mean sea level (MSL), above the highest runway elevation in the touchdown zone at which a missed approach must be initiated if the required visual reference has not been established. This term is used only in procedures where an electronic glide slope provides the reference for descent, as in an instrument landing system (ILS) or precision approach radar (PAR).

DME Distance Measuring Equipment Arc. A course, indicated as a constant DME distance, around a navigation facility which provides distance information.

DME Distance. The line of sight distance (slant range) from the source of the DME signal to the receiving antenna.

FAC Final Approach Course.

FAF Final Approach Fix.

Flight Inspection. In-flight investigation and certification of certain operational performance characteristics of electronic and visual navigation facilities by an authorized inspector in conformance with Order 8200.1, U. S. Standard Flight Inspection Manual.

Gradient. A slope expressed in feet per mile, or as a ratio of the horizontal to the vertical distance. For example, 40:1 means 40 feet horizontally to 1 foot vertically.

GPI Ground Point of Intercept. A point in the vertical plane on the runway centerline at which it is assumed that the straight line extension of the glide slope intercepts the runway approach surface baseline.

HAA Height above airport elevation.

HAT Height above touchdown zone elevation.

IAC Initial Approach Course.

IAF Initial Approach Fix.

IC Intermediate Course.

IF Intermediate Fix

JAL High Altitude Approach and Landing (Chart).

LOC Localizer. The component of an ILS which provides lateral guidance with respect to the runway centerline.

LDA Localizer type directional aid. A facility of comparable utility and accuracy to a LOC, but which is not part of a full ILS and may not be aligned with the runway.

LPV - Lateral Precision Performance with Vertical Guidance

MAP Missed Approach Point (paragraph 272).

MDA Minimum Descent Altitude (paragraph 310)

MHA Minimum Holding Altitude.

NDB (ADF) Non Directional Beacon (Airborne Automatic Direction Finder). A combined term which indicates that an NDB provides an electronic signal for use with ADF equipment.

Obstacle. An existing object, object of natural growth, or terrain at a fixed geographical location which may be expected at a fixed location within a prescribed area, with reference to which vertical clearance is or must be provided during flight operation. For example, with reference to mobile objects, a moving vehicle 17 feet high is assumed to be on an Interstate Highway, 15 feet high on other highways, and 23 feet high on a railroad track, except where limited to certain heights controlled by use or construction. The height of a ship's mast is assumed according to the types of ships known to use an anchorage.

Obstacle Clearance. The vertical distance between the lowest authorized flight altitude and a prescribed surface within a specified area.

Obstacle Clearance Boxes $\boxed{500}$. When used in figures which depict approach segments, these boxes indicate the obstacle clearance requirements in feet.

Operational Advantage. An improvement which benefits the users of an instrument procedure. Achievement of lower minimums or authorization for a straight-in approach with no derogation of safety is an example of an operational advantage. Many of the options in TERPS are specified for this purpose. For instance, the flexible final approach course alignment criteria may permit the ALS to be used for reduced visibility credit by selection of the proper optional course.

Optimum Most Favorable. As used in TERPS, optimum identifies the value, which should be used wherever a choice is available.

Positive Course Guidance. A continuous display of navigational data which enable an aircraft to be flown along a specific course line.

Precipitous Terrain. Terrain characterized by steep or abrupt slopes.

Precision and Nonprecision. These terms are used to differentiate between navigational facilities which provide a combined azimuth and glide slope guidance to a runway (Precision) and those that do not. The term nonprecision refers to facilities without a glide slope, and does not imply an unacceptable quality of course guidance.

Primary Area. The area within a segment in which full obstacle clearance is applied.

ROC Required Obstacle Clearance.

Runway Environment. The runway threshold or approved lighting aids or other markings identifiable with the runway.

Secondary Area. The area within a segment in which ROC is reduced as distance from the prescribed course is increased.

Segment. The basic functional division of an instrument approach procedure. The segment is oriented with respect to the course to be flown. Specific values for determining course alignment, obstacle clearance areas, descent gradients, and obstacle clearance requirements are associated with each segment according to its functional purpose.

Service Volume. That volume of airspace surrounding a VOR, TACAN, or VORTAC facility within which a signal of usable strength exists and where that signal is not operationally limited by co-channel interference. The advertised service volume is defined as a simple cylinder of airspace for ease in planning areas of operation.

TCH Threshold Crossing Height. The height of the straight line extension of the glide slope above the runway at the threshold.

TDZ Touchdown Zone. The first 3,000 feet of runway beginning at the threshold.

TDZE Touchdown Zone Elevation. The highest runway centerline elevation in the touchdown zone.

Transition Level. The flight level below which heights are expressed in feet MSL and are based on an approved station altimeter setting.

VDP Visual Descent Point. The VDP is a defined point on the final approach course of a nonprecision straight-in approach procedure from which normal descent from the MDA to the runway touchdown point may be commenced, provided visual reference is established.

3. ACRONYMS AND ABBREVIATIONS. Many acronyms and abbreviations for old and new aviation terms are used throughout this order. Users of this order can refer to the following alphabetical listing of frequently used acronyms and abbreviations:

AAF	Airway Facilities Service
ABM	abeam
AC	Advisory Circular
ADF	automatic direction finder
AFM	Airplane Flight Manual
AFS	Flight Standards Service
AFSS	Automated Flight Service Station
AGL	above ground level
AIM	Aeronautical Information Manual
ALPA	Air Line Pilots Association
ALSF-1	approach lighting system with sequenced flashing lights (CAT I Configuration)
ALSF-2	approach lighting system with sequenced flashing lights (CAT II Configuration)
AOPA	Aircraft Owners and Pilots Association
APV	approach with vertical guidance (ICAO)
ARA	airborne radar approach
ARC	Airport Reference Code
ARDH	achieved reference datum height
ARINC	Aeronautical Radio, Inc.
ARP	airport reference point
ARSR	air route surveillance radar
ARTCC	Air Route Traffic Control Center
ASBL	approach surface baseline
ASOS	automated surface observing system
ASR	airport surveillance radar
AT	Air Traffic
ATA	Air Transport Association
ATC	Air Traffic Control
ATD	along track distance
ATRK	along track
ATS	Air Traffic Service
AVN	Aviation System Standards
AWO	all weather operations
AWOP	All Weather Operations Panel
AWO/PM	All Weather Operations/Program Manager
AWOS	automated weather observation system
AWS	Aviation Weather System
Baro VNAV	Barometric vertical navigation
BC	back course
CAT	Category
CF	course to fix
CFIT	controlled flight into terrain
CFR	Code of Federal Regulations
CG	climb gradient
CGL	circling guidance light
CHDO	Certificate Holding District Office
CIH	climb-in-hold
CMO	Certificate Management Office
CMT	Certificate Management Team
CONUS	Continental United States
COP	changeover point
CRM	collision risk model
CW	course width
CWSU	Center Weather Service Unit
CY	Calendar Year
DA	decision altitude
dB	decibel
DCG	desired climb gradient
DER	departure end of runway
DF	direct to fix

DF	direction finder
DG	descent gradient
DH	decision height
DME	distance measuring equipment
DOD	Department of Defense
DOT	Department of Transportation
DP	departure procedure
DR	dead reckoning
DRL	departure reference line
DRP	departure reference point
DTA	distance turn anticipation
DVA	diverse vector area
EARTS	en route automated radar tracking system
EDA	elevation differential area
ESA	emergency safe altitudes
ESV	expanded service volume
FAA	Federal Aviation Administration
FAATC	FAA Technical Center
FAC	final approach course
FAF	final approach fix
FAP	final approach point
FAR	Federal Aviation Regulations
FAS	final approach segment
FATO	final approach and takeoff area
FAWP	final approach waypoint
FDC	Flight Data Control
FDR	Flight Data Record
FDT	fix displacement tolerance
FEP	final end point
FIFO	Flight Inspection Field Office
FMS	flight management system
FPAP	flight path alignment point
FPCP	flight path control point
FPO	Flight Procedures Office
FR	Federal Register
FSDO	Flight Standards District Office
FSS	Flight Service Station
FTE	flight technical error
~~FTIP~~	~~Foreign terminal instrument procedure~~
FTP	fictitious threshold point
GA	general Aviation
GCA	ground controlled approach
GH	Geoid Height
GLONASS	Global Orbiting Navigation Satellite System
GLS	GNSS Landing System
GNSS	Global Navigation Satellite System
GP	glidepath
GPA	glidepath angle
GPI	ground point of intercept
GPS	Global Positioning System
GRI	group repetition interval
GS	glide slope
HAA	height above airport
HAE	height above ellipsoid
HAH	height above helipoint

HAI	Helicopter Association International
HAL	height above landing area elevation
HAS	height above surface
HAT	height above touchdown
HATh	height above threshold
HCH	heliport crossing height
HF	high frequency
HIRL	high intensity runway lights
HRP	heliport reference point
HUD	heads-up display
IAC	initial approach course
IAF	initial approach fix
IAP	instrument approach procedure
IAPA	instrument approach procedure automation
IC	intermediate course
ICA	initial climb area
ICAB	ICA baseline
ICAE	ICA end-line
ICAO	International Civil Aviation Organization
ICWP	initial course waypoint
IDF	initial departure fix
IF	intermediate fix
IF	initial fix
IF/IAF	intermediate/initial approach fix
IFR	instrument flight rules
ILS	instrument landing system
IMC	instrument meteorological conditions
INS	inertial navigation system
IPV	instrument procedure with vertical guidance
IRU	inertial reference unit
ISA	International Standard Atmosphere
kHz	kilohertz
KIAS	knots indicated airspeed
LAAS	Local Area Augmentation System
LAB	landing area boundary
LAHSO	land and hold short operations
~~LDA~~	~~localizer type directional aid~~
LDIN	lead-in lighting system
LF	low frequency
LIRL	low intensity runway lights
LNAV	lateral navigation
LPV	Lateral Precision Performance with Vertical Guidance
LOA	Letter of Agreement
LOB	lines of business
LOC	localizer
LOM	locator outer marker
LORAN	long range navigation system
LTP	landing threshold point
MALS	minimum intensity approach lighting system
MALSF	minimum intensity approach lighting system with sequenced flashing

MALSR	minimum intensity approach lighting system with runway alignment indicator lights
MAP	missed approach point
MCA	minimum crossing altitude
MDA	minimum descent altitude
MEA	minimum en route altitude
MHA	minimum holding altitude
MHz	megahertz
MIA	minimum IFR altitudes
MIRL	medium intensity runway lights
MLS	Microwave Landing System
MM	middle marker
MOA	Memorandum of Agreement
MOA	military operations area
MOC	minimum obstacle clearance
MOCA	minimum obstruction clearance altitude
MOU	Memorandum of Understanding
MRA	minimum reception altitude
MSA	minimum safe/sector altitude
MSL	mean sea level
MTA	minimum turn altitude
MVAC	minimum vectoring altitude chart
NAD	North American Datum
NAS	National Airspace System
NAVAID	navigational aid
NAWAU	National Aviation Weather Advisory Unit
NBAA	National Business Aviation Association
NDB	nondirectional radio beacon
NFDC	National Flight Data Center
NFDD	National Flight Data Digest
NFPO	National Flight Procedures Office
NM	nautical mile
NOAA	National Oceanic and Atmospheric Administration
NOS	National Ocean Service
NOTAM	Notice to Airmen
NOZ	normal operating zone
NPA	nonprecision approach
NTSB	National Transportation Safety Board
NTZ	no transgression zone
NWS	National Weather Service
OC	obstruction chart
OCA	obstacle clearance altitude
OCH	obstacle clearance height
OCS	obstacle clearance surface
ODALS	omnidirectional approach lighting system
OEA	obstruction evaluation area
OE/AAA	Obstruction Evaluation/Airport Airspace Analysis
OFA	object free area
OIS	obstacle identification surface
OM	outer marker
ORE	obstacle rich environment
OSAP	off-shore approach procedure
PA	precision approach
PAPI	precision approach path indicator
PAR	precision approach radar
PCG	positive course guidance
PDA	preliminary decision altitude
PFAF	precision final approach fix
PGPI	pseudo ground point of intercept
PinS	point-in-space
PLS	precision landing system
POC	point of contact
PRM	precision runway monitor
PT	procedure turn
PVG	positive vertical guidance
PVGSI	pseudo visual glide slope indicator
RA	radio altimeter
RAA	Regional Airline Association
RAIL	runway alignment indicator lights
RAPCON	radar approach control
RASS	remote altimeter setting source
RCL	runway centerline
RDP	reference datum point
REIL	runway end identifier lights
RF	radio frequency
RF	radius to fix
RNAV	area navigation
RNP	required navigation performance
ROC	required obstacle clearance
RPI	runway point of intercept
RRP	runway reference point
RTCA	Radio Technical Commission for Aeronautics
RVR	runway visual range
RWP	runway threshold waypoint
RWT	runway threshold
RWTE	runway threshold evaluation
RWY	runway
SALS	short approach lighting system
SATNAV	satellite navigation
SCG	standard climb gradient
SDF	simplified directional facility
SDF	step-down fix
SER	start end of runway
SIAP	standard instrument approach procedure
SID	standard instrument departure
SM	statute mile
SSALF	short simplified approach lighting system with sequenced flashers
SSALR	short simplified approach lighting system with runway alignment indicator lights
STAR	standard terminal arrival route
STOL	short takeoff and landing
TAA	terminal arrival area
TACAN	tactical air navigational aid
TCH	threshold crossing height
TD	time difference
TDP	touchdown point
TDZ	touchdown zone

TDZE	touchdown zone elevation
TDZL	touchdown zone lights (system)
TERPS	terminal instrument procedures
TF	track to fix
TL	Transmittal Letter
TLOF	touchdown and life-off area
TLS	transponder landing system
TORA	takeoff runway available
TP	tangent point
TPD	tangent point distance
TRACON	terminal radar approach control facility
TSO	technical standard order
TWP	turn waypoint
UHF	ultra high frequency
USA	U.S. Army
USAF	U.S. Air Force
USCG	U.S. Coast Guard
USMC	U.S. Marine Corps
USN	U.S. Navy
VA	heading to altitude
VASI	visual approach slope indicator
VCA	visual climb area
VCOA	visual climb over airport
VDA	vertical descent area
VDP	visual descent point
VFR	visual flight rules
VGA	vertically guided approach
VGSI	visual glide slope indicator
VHF	very high frequency
VLF	very low frequency
VMC	visual meteorological conditions
VNAV	vertical navigation
VOR	very high frequency omnidirectional radio range
VOR/DME	very high frequency omnidirectional radio range collocated with distance measuring equipment
VORTAC	very high frequency omnidirectional radio range collocated with tactical air navigation
VPA	vertical path angle
VSDA	visual segment descent angle
VTOL	vertical take-off and landing
WAAS	Wide Area Augmentation System
WCH	wheel crossing height
XTRK	crosstrack

FAA ORDER **8260.3B**

Army	TM 95-226
Navy	OPNAV Inst. 3722.16C
Coast Guard	CG 318
Air Force	AFMAN 11-226(I)

UNITED STATES STANDARD
FOR
TERMINAL
INSTRUMENT
PROCEDURES
(TERPS)

VOLUME 2

NONPRECISION APPROACH PROCEDURE (NPA) CONSTRUCTION

RESERVED

U. S. DEPARTMENT OF TRANSPORTATION

FEDERAL AVIATION ADMINISTRATION

FAA ORDER **8260.3B**

Army
Navy
Coast Guard
Air Force

TM 95-226
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CG 318
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UNITED STATES STANDARD FOR TERMINAL INSTRUMENT PROCEDURES (TERPS)

VOLUME 3

Precision Approach (PA) and Barometric Vertical Navigation (Baro VNAV) Approach Procedure Construction

U. S. DEPARTMENT OF TRANSPORTATION

FEDERAL AVIATION ADMINISTRATION

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APPENDIX 5. THRESHOLD CROSSING HEIGHT (TCH), GROUND POINT OF INTERCEPT (GPI), AND RUNWAY POINT OF INTERCEPT (RPI) CALCULATION (4 Pages)

CHAPTER 1. GENERAL INFORMATION

1.0 PURPOSE.

This TERPS volume contains final and initial missed approach segment construction criteria applicable to instrument approach procedures that provide positive glidepath guidance. Apply this criteria to approaches based on instrument landing system (ILS), microwave landing system (MLS), precision approach radar (PAR), transponder landing system (TLS), wide area augmentation system (WAAS), local area augmentation system (LAAS), barometric vertical navigation (Baro-VNAV), and future 3-dimensional navigational systems.

1.1 BACKGROUND.

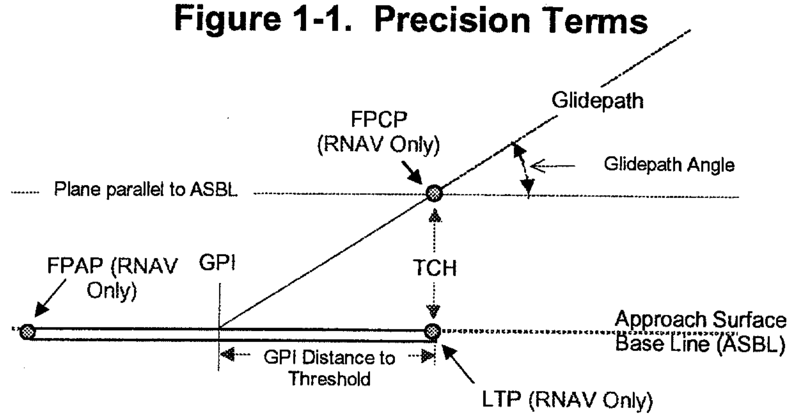
The ILS defined the navigational aid (NAVAID) performance standard for precision vertical and lateral guidance systems. Several different NAVAID's providing positive vertical guidance have evolved since the inception of ILS. NAVAID's capable of supporting Category I landing minimums are: ILS, PAR, MLS, TLS, WAAS, and LAAS. NAVAID's capable of providing Category II/III landing minimums are: ILS, MLS, and LAAS. A NAVAID capable of supporting Category I/II/III minimums does not qualify as a precision approach (PA) system without supporting ground infrastructure. Certain airport and obstruction clearance requirements are mandatory for the system to be considered a PA system and achieve the LOWEST minimums. These requirements are contained in AC 150/5300-13, Airport Design; and Order 8260.3, Volume 3, Precision Approach (PA), Barometric Vertical Navigation (Baro VNAV) Approach Procedure Construction, and appropriate military directives. When mandatory ground infrastructure requirements are not met, these NAVAID's may provide a vertically guided stabilized final approach descent, but command higher landing minimums. Additionally, some flight management system (FMS) avionics suites are equipped with Baro-VNAV systems that provide stabilized descent guidance.

1.2 DEFINITIONS.

1.2.1 Approach Surface Base Line (ASBL).

A horizontal line tangent to the surface of the earth at the runway threshold (RWT) point, aligned with the final approach course (see figure 1-1).

Figure 1-1. Precision Terms



1.2.2 Barometric Altitude).

Altitude above the orthometric Geoid surface; i.e., mean sea level (MSL), based on atmospheric pressure measured by an aneroid barometer. This is the most common method of determining aircraft altitude.

1.2.3 Barometric Vertical Navigation (Baro VNAV).

RNAV and Non-RNAV. Positive vertical guidance relative to a computed glidepath that is based on the difference between published altitudes at two specified points or fixes.

1.2.4 Decision Altitude (DA).

A specified altitude in reference to mean sea level in an approach with vertical guidance at which a missed approach must be initiated if the required visual references to continue the approach have not been established.

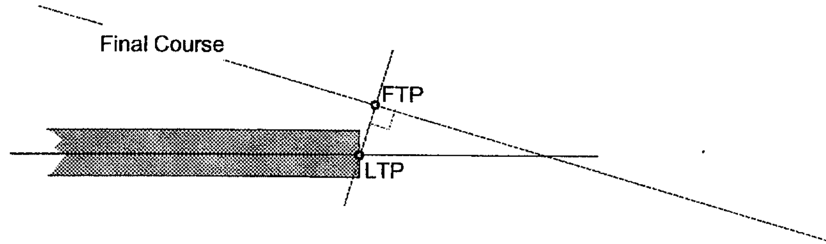
1.2.5 Departure End of Runway (DER).

The end of the runway that is opposite the landing threshold. It is sometimes referred to as the stop end of runway.

1.2.6 Fictitious Threshold Point (FTP).

The equivalent of the landing threshold point (LTP) when the final approach course is offset from runway centerline. It is the intersection of the final course and a line perpendicular to the final course that passes through the LTP. FTP elevation is the same as the LTP (see figure 1-2).

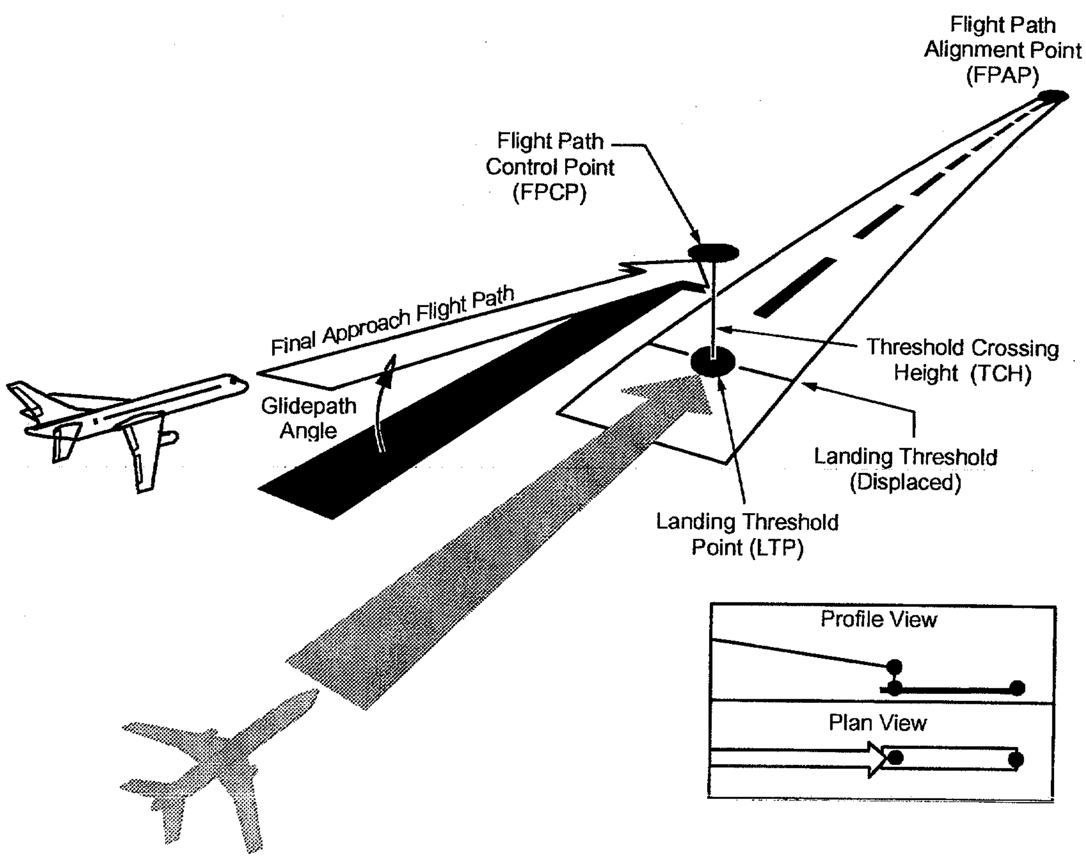
Figure 1-2. Fictitious Threshold Point



1.2.7 Flight Path Alignment Point (FPAP). [RNAV Only]

The FPAP is a 3D point defined by World Geodetic System (WGS)-84/North American Datum (NAD)-83 latitude, longitude, MSL elevation, (see figures 1-1 and 1-3). The FPAP is used in conjunction with the LTP and the geometric center of the WGS-84 ellipsoid to define the vertical plane of a PA RNAV final approach course. The approach course may be offset up to 3° by establishing the FPAP left or right of centerline along an arc centered on the LTP.

Figure 1-3. Precision Approach Path Points (Straight-In)



1.2.8 Flight Path Control Point (FPCP). [RNAV Only]

An imaginary point above the LTP from which the glidepath mathematically emanates. It is in a vertical plane containing the LTP and FPAP. The FPCP has the same geographic coordinates as the LTP. The elevation of the FPCP is the sum of LTP elevation and the TCH value (see figure 1-3).

1.2.9 Geoid Height (GH). [RNAV Only]

The height of the Geoid (reference surface for orthometric or MSL heights) relative to the WGS-84 ellipsoid. It is a positive value when the Geoid is above the WGS-84 ellipsoid and negative when it is below. The value is used to convert an MSL elevation to an ellipsoidal or geodetic height - the height above ellipsoid.

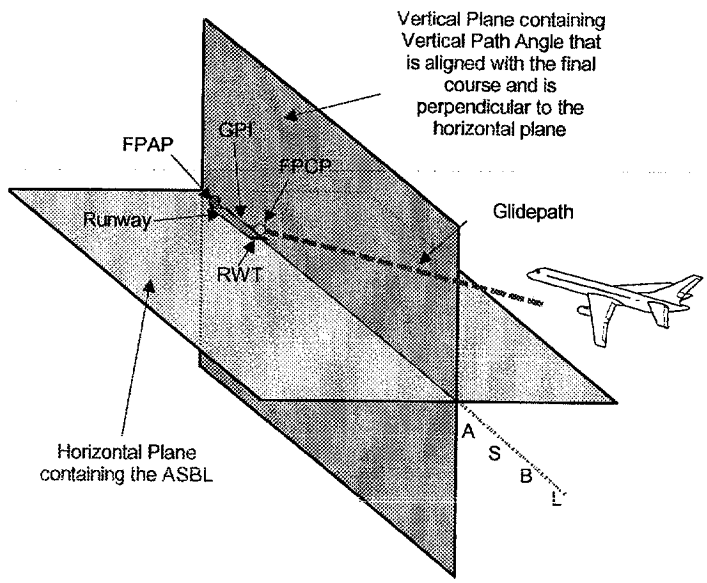
1.2.10 Glidepath Angle (GPA).

The angular displacement of the glidepath from a horizontal plane that passes through the LTP/FTP. This angle is published on approach charts (e.g., 3.00°, 3.20°, etc.).

1.2.11 Ground Point of Intercept (GPI).

A point in the vertical plane containing the glidepath where the vertical path intercepts the ASBL. GPI is expressed as a distance from RWT (see figure 1-4).

Figure 1-4. 3D Path & Course



1.2.12 Height Above Ellipsoid (HAE). [RNAV Only]

A height expressed in feet above the WGS-84 ellipsoid. This value differs from a height expressed in feet above the geoid (essentially MSL) because the reference surfaces (WGS-84 Ellipsoid and the Geoid) do not coincide. To convert an MSL height to an HAE height, algebraically add the geoid height value to the MSL value. HAE elevations are not used for instrument procedure construction, but are documented for inclusion in airborne receiver databases.

EXAMPLE:	Given:	KOUN RWY 35	Runway ID
		N 35 14 31.65	Latitude
		W 97 28 22.84	Longitude
		1177.00	MSL Elevation
		-87.29 feet (-26.606 m)	Geoid Height (GH)

HAE = MSL + GH

HAE = 1177 + (-87.29)

HAE = 1089.71

1.2.13 Height Above Touchdown (HAT).

The HAT is the height of the DA above touchdown zone elevation (TDZE).

1.2.14 Inner-Approach Obstacle Free Zone (OFZ).

The airspace above a surface centered on the extended runway centerline. It applies to runways with an approach lighting system.

1.2.15 Inner-Transitional OFZ.

The airspace above the surfaces located on the outer edges of the runway OFZ and the inner-approach OFZ. It applies to runways with approach visibility minimums less than ¾ statute mile.

1.2.16 Landing Threshold Point (LTP).

The LTP is a 3D point at the intersection of the runway centerline and the runway threshold. It is defined by WGS-84/NAD-83 latitude, longitude, MSL elevation, and geoid height (see figure 1-1). It is used in conjunction with the FPAP and the geometric center of the WGS-84 ellipsoid to define the vertical plane of an RNAV final approach course. LTP elevation applies to the FTP when the final approach course is offset from runway centerline.

1.2.17 Lateral Navigation (LNAV). [RNAV Only]

Azimuth navigation without positive vertical guidance. This type of navigation is associated with nonprecision approach procedures.

1.2.18 Microwave Landing System/Mobile Microwave Landing System (MLS/MMLS). [DOD Only)

MLS/MMLS can be configured in two ways; "Split Site" where the azimuth and elevation antennas are sited the same as an ILS, or "Collocated Site" where the azimuth and elevation antennas are located together along side the runway. "Split Site" is the normal configuration for "fixed" MLS locations to meet the capability of standard MLS avionics receiver equipment. Aircraft that will use MLS/MMLS procedures configured as a "Collocated Site" must have a special MLS avionics receiver capable of computing the offset runway centerline location. These procedures will have the following caveat: "COMPUTED APPROACH: FOR USE BY AIRCRAFT CAPABLE OF COMPUTING OFFSET RUNWAY CENTERLINE ONLY." Since the MMLS has a selectable azimuth and glide slope, procedures will be published with the caveat: "FLYING OTHER THAN PUBLISHED AZIMUTH AND/OR GS ANGLE RENDERS THE PROCEDURE UNUSABLE." MMLS equipment computing capability for "collocated" configuration requires that all system components (DME/P, AZ, and EL) must be operating, thus the following caveat must be published: "ALL SYSTEM COMPONENTS MUST BE OPERATIONAL."

1.2.19 Object Free Area (OFA).

An area on the ground centered on a runway, taxiway, or taxilane centerline provided to enhance the safety of aircraft operations by having the area free of objects, except for objects that need to be located in the OFA for air navigation or aircraft ground maneuvering purposes.

1.2.20 Obstacle Clearance Surface (OCS).

An inclined obstacle evaluation surface associated with a glidepath. The separation between this surface and the glidepath angle at any given distance from GPI defines the MINIMUM required obstruction clearance at that point.

1.2.21 Positive Vertical/Horizontal Guidance.

Glidepath or course guidance based on instrumentation indicating magnitude and direction of deviation from the prescribed glidepath or course on which obstruction clearance is based.

1.2.22 Precision Approach (PA).

An approach based on a navigation system that provides positive course and vertical path guidance conforming to ILS or MLS system performance standards contained in ICAO Annex 10. To achieve lowest minimums, the ground infrastructure must meet requirements contained in AC 150/5300-13 and TERPS Volume 3.

1.2.23 Precision Approach Radar (PAR).

A ground radar system displaying an aircraft on final approach in plan and profile views in relation to glidepath and course centerlines. Air traffic controllers issue course line and glidepath information to the pilot. The pilot alters course and rate of descent in response to gain course and glidepath alignment. Military pilots may achieve 100′ HAT and 1/4 mile visibility minimums with PAR.

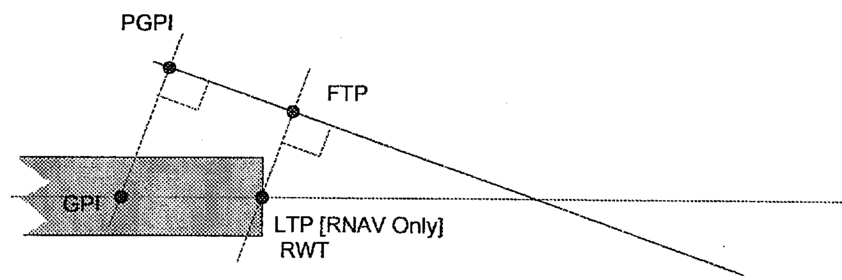
1.2.24 **Precision Final Approach Fix (PFAF).** Applicable to all PA approach procedures.

A 2D point located on the final approach course at a distance from LTP/FTP where the GPA intercepts the intermediate segment altitude (glidepath intercept altitude). The PFAF marks the outer end of the PA final segment.

1.2.25 **Pseudo Ground Point of Intercept (PGPI).**

Phantom location abeam the GPI when the approach course is offset. PGPI elevation is the same as ASBL (see figure 1-5).

Figure 1-5. PGPI and FTP Locations



1.2.26 **Radio Altimeter Height (RA).**

An indication of the vertical distance between a point on the nominal glidepath at DA and the terrain directly beneath this point.

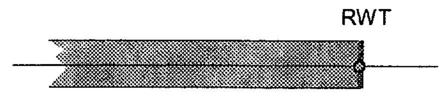
1.2.27 **Required Navigation Performance (RNP).**

A statement of the navigation performance accuracy necessary for operation within a defined airspace. Note that there are additional requirements, beyond accuracy, applied to a particular RNP type.

1.2.28 **Runway Threshold (RWT).**

The RWT marks the beginning of that part of the runway usable for landing (see figure 1-6). It extends the full width of the runway. The RWT geographic coordinates identify the point the runway centerline crosses the RWT.

Figure 1-6. Threshold



1.2.29 Three-Dimensional (3D) Point/Waypoint. [RNAV Only]

A waypoint defined by WGS-84 latitude and longitude coordinates, MSL elevation, and GH.

1.2.30 Touchdown Zone Elevation (TDZE).

The highest elevation in the first 3,000 feet of the landing surface.

1.2.31 Two-Dimensional (2D) Point/Waypoint. [RNAV Only]

A waypoint defined by WGS-84 latitude and longitude coordinates.

1.2.32 Wide Area Augmentation System (WAAS). [RNAV Only]

A method of navigation based on the GPS. Ground correction stations transmit position corrections that enhance system accuracy and add VNAV features.

CHAPTER 2. GENERAL CRITERIA

2.0 POLICY DIRECTIVES.

The final and missed approach criteria described in this order supersede the other publications listed below, except as noted. The following orders apply unless otherwise specified in this order:

2.0.1 **8260.3**, United States Standard for Terminal Instrument Procedures (TERPS), Volume 1;

2.0.2 **8260.19**, Flight Procedures and Airspace;

2.0.3 **8260.38,** Civil Utilization of Global Positioning System (GPS);

2.0.4 **8260.44,** Civil Utilization of Area Navigation (RNAV) Departure Procedures;

2.0.5 **8260.45,** Terminal Arrival Area (TAA) Design Criteria; and

2.0.6 **7130.3**, Holding Pattern Criteria.

2.1 DATA RESOLUTION.

Perform calculations using at least 0.01 unit of measure. Document latitudes and longitudes to the nearest one hundredth (0.01") arc second; elevations to the nearest hundredth (0.01') foot; courses, descent and glidepath angles to the nearest one hundredth (0.01°) degree, and distances to the nearest hundredth (0.01) unit. Where other publications require different units and/or lesser resolution, use established conversion and rounding methods.

2.2 PROCEDURE IDENTIFICATION.

2.2.1 RNAV.

Title a GPS, WAAS, or Baro-VNAV approach procedure: RNAV (sensor) RWY (number). Examples: **RNAV (GPS) RWY 13, RNAV (GPS, DME/DME) Z RWY 34R**. A typical RNAV approach chart will depict minima for LPV, LNAV/VNAV, LNAV, and circling. Title LAAS procedures: GLS RWY (Runway number). Example: GLS RWY 16.

2.2.2 Non-RNAV.

Title an ILS, MLS, TLS, or LDA/glide slope procedure: XXX RWY (Runway number). Examples: **ILS RWY 16, ILS or LOC RWY 16, ILS or LOC Z RWY 5, MLS RWY 28, TLS RWY 4, LDA RWY 31L** (chart noted glide slope required).

2.3 EN ROUTE, INITIAL, AND INTERMEDIATE SEGMENTS.

Apply criteria in TERPS, Volume 1 to non-RNAV approaches. Apply criteria in Order 8260.38, paragraphs 8-12, to construct the RNAV approaches except as noted. If a TAA is desired, apply Order 8260.45, paragraph 5.

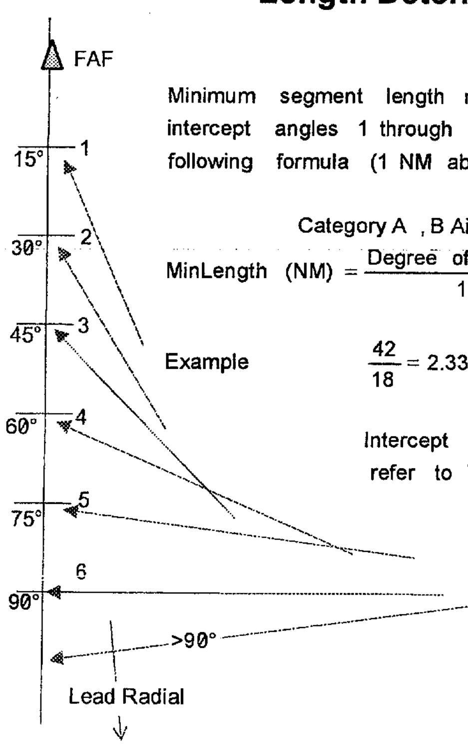
TLS NOTE: Establish an intermediate fix (IF) defined by NAVAID's not associated with the TLS. The IF shall be on the final approach course. Establish a holding pattern at the IF (based on an inbound course to the IF) for use in the event the TLS azimuth course is not acquired.

2.3.1 Minimum Intermediate Segment Length.

The intermediate segment blends the initial approach segment into the final approach segment. It begins at the IF and extends along the final approach course extended to the PFAF. Where a turn from the initial course to the final approach course extended is required, the initial course shall intercept at or before the IF.

2.3.1 **a. Length.** The MINIMUM length of the intermediate segment is 1 NM. Minimum segment length varies where a turn is required at the IF. The length is determined by the magnitude of heading change in the turn on to the final approach course extended (see figure 2-1A). The maximum angle of intersection is 90° unless a lead radial as specified in TERPS Volume 1, paragraph 232a, is provided and the length of the intermediate segment is increased as specified in TERPS Volume 1, table 3.

Figure 2-1A. Minimum Intermediate Segment Length Determined by Intercept Angle



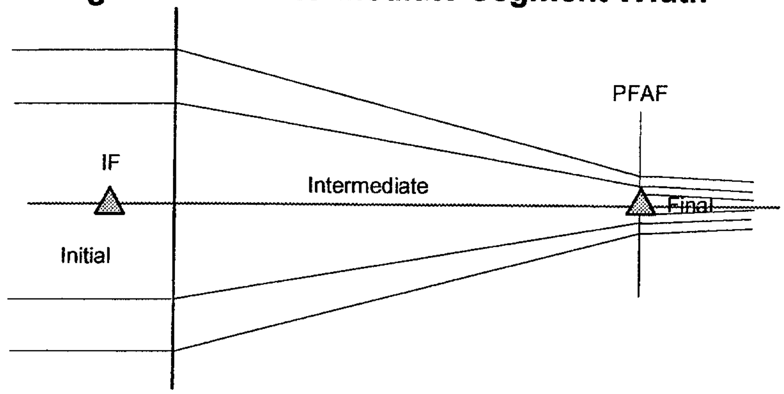
Minimum segment length may be calculated for intercept angles 1 through 90 degrees using the following formula (1 NM absolute minimum) :

	Category A , B Aircraft	Category C, D, E Aircraft
	$\text{MinLength (NM)} = \frac{\text{Degree of Intercept}}{18}$	$\text{Min Length (NM)} = \frac{\text{Degree of Intercept}}{15}$
Example	$\frac{42}{18} = 2.33$	$\frac{42}{15} = 2.8$

Intercept angles greater than 90 degrees refer to TERPS Volume 1, Table 3

2.3.1 **b. Width.** The intermediate trapezoid begins at the width of the initial segment at the latest point the IF can be received, to the width of the final segment at the plotted position of the PFAF (see figure 2-1B).

Figure 2-1B. Intermediate Segment Width



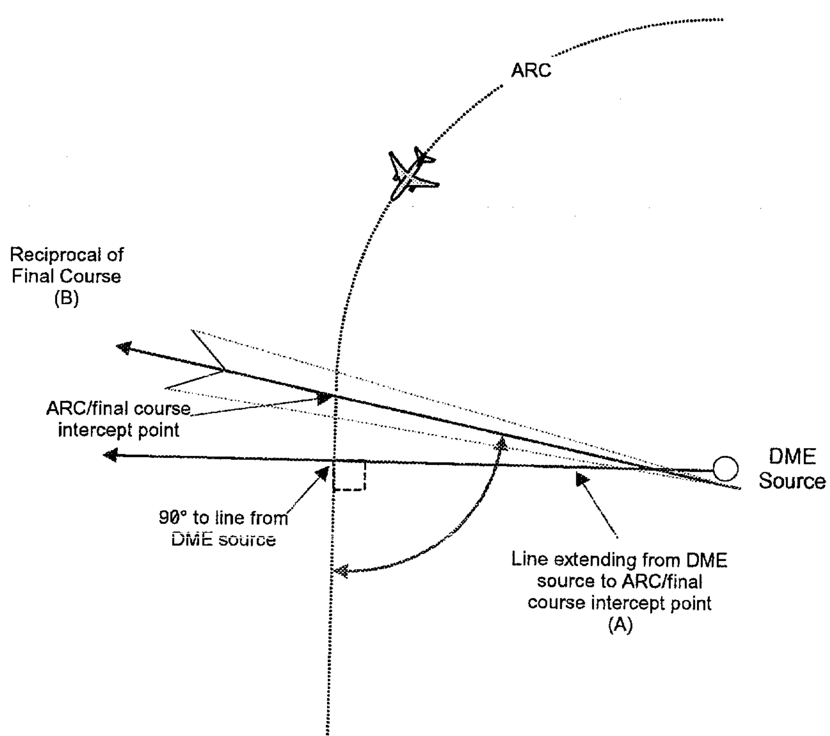
2.3.2 **Determining FAC Intercept Angle Where DME Source is not Collocated with FAC Facility.**

Determine the intercept initial/intermediate segment intercept angle on approach procedures utilizing ARC initial segments using the following formulas.

2.3.2 **a. DME source** on the same side of course as the aircraft (see figure 2-2).

$90 - |A - B| = \text{Intercept Angle} \quad \text{Example: } 90 - |270 - 285| = 75°$

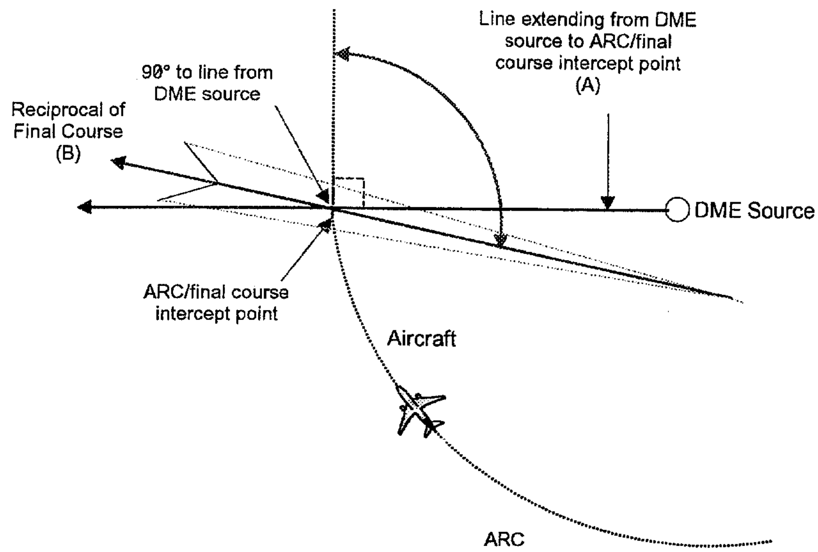
Figure 2-2. Aircraft on the Same Side of Localizer as DME Sources



2.3.2 b. **DME source** on opposite side of course as the aircraft (see figure 2-3).

$$90 + |A - B| = \text{Intercept Angle} \qquad \text{Example: } 90 + |270 - 285| = 105^\circ$$

Figure 2-3. Aircraft on Opposite Side of Localizer as DME Sources



2.4 RNP VALUES.

Procedures designed under this order may be flown by aircraft with navigation systems certified to RNP values. Each segment of an RNAV procedure has a specific RNP value. Table 2-1 lists RNP values (95% accuracy) by segment type.

Table 2-1. Segment RNP Values

Segment	Lateral (NM) RNAV
En Route	2.0
Initial	1.0
Intermediate	0.5
Final	0.30
LNAV	0.30
Missed Approach	1.0

2.5 MAXIMUM AUTHORIZED GPA'S.

Tables 2-2A, 2-2B, and 2-2C list the MAXIMUM allowable GPA's and MINIMUM visibility by aircraft category, and MAXIMUM TCH values for allowing credit for approach lighting systems (USAF NA). Use Volume 1, Chapter 3 for computing landing minimums). Design all approach procedures to the same runway with the same glidepath angle and TCH. Angles above 3.0° require approval of FAA Flight Standards Service or the appropriate military authority.

Table 2-2A. Maximum GPA's

Category	GPA
A (80 knots or less)	6.4
A (81-90 knots)	5.7
B	4.2
C	3.6
D&E	3.1

2.5.1 RNAV Glidepath Angles.

If a non-RNAV PA system (ILS, MLS, TLS, or PAR) serves the same runway as an RNAV PA system, the RNAV glidepath angle and TCH should match the non-RNAV system.

2.5.2 VGSI Angles.

A VGSI is recommended for all runways to which an instrument approach is published. Where installed, the VGSI angle and TCH should match the glidepath angle of vertically guided approach procedures to the runway.

Table 2-2B. Standard PA Landing Minimums

GLIDEPATH ANGLE (WITH APPROACH LIGHT CONFIGURATION)		MINIMUM HAT*	AIRCRAFT CATEGORY A	B	C	D & E
			MINIMUM VISIBILITY			
3.00° — 3.10°	★	200	¾ 4000			
	#	200	½ 2400			
	$	200	1800			
3.11° — 3.30°	★	200	¾ 4000		NA	
	★	250	¾ 4000		1 5000	NA
	#	200	½ 2400		NA	
	#	250	½ 2400		¾ 4000	NA
	$	200	1800		NA	
	$	250	1800		½ 2400	NA
3.31° — 3.60°	★	200	¾ 4000		NA	
	★	270	¾ 4000		1 5000	NA
	#	200	½ 2400		NA	
	#	270	½ 2400		¾ 4000	NA
	$	200	2000		NA	
	$	270	2000		½ 2600	NA
3.61° — 3.80°	★	200	¾ 4000		NA	
	#	200	½ 2400		NA	
3.81° — 4.20°	★	200	¾ 4000	NA		
	★	250	¾ 4000	1 5000	NA	
	#	200	½ 2400	NA		
	#	250	½ 2400	¾ 4000	NA	
4.21° — 5.00°	★	250	¾ 4000	NA		
	#	250	½ 2400	NA		
5.01° — 5.70°	★	300	1 5000	NA		
	#	300	¾ 4000	NA		
5.71° — 6.40° AIRSPEED NTE 80 KNOTS	★	350	1 ¼	NA		
	#	350	1 5000	NA		

* The HAT shall not be less than 200 feet for civil operations, or 100 feet for military operations.

★= No Lights $ = # Plus TDZ/CL Lights # = MALSR, SSALR, ALSF NA = Not authorized

NOTE: For a HAT higher than the minimum, the visibility (prior to applying credit for lights) shall equal the distance from DA/MAP to RWT, or

(a) ¾ mile up to 5.00°, or
(b) 1 mile 5.01° through 5.70°, or
(c) 1 ¼ miles 5.71° through 6.40°, whichever is the greater.

2.6 GLIDE SLOPE THRESHOLD CROSSING HEIGHT REQUIREMENTS.

2.6.1 Category I Threshold Crossing Height (TCH) Requirements.

2.6.1 a. **Standard.** The glide slope should be located considering final approach obstructions and achieving TCH values associated with the greatest table 2-3 wheel height group applicable to aircraft normally expected to use the runway. The TCH should provide a 30-foot wheel crossing height (WCH).

2.6.1 b. **Deviations from Standard.** The TCH shall provide a WCH of no less than 20 feet or greater than 50 feet for the appropriate wheel height group. These limits shall not be exceeded unless formally approved by a Flight Standards waiver as outlined in Order 8260.19C or by the appropriate military authority.

NOTE: 60 feet is the maximum TCH.

2.6.1 c. **Displaced Threshold Considerations.** The TCH over a displaced threshold can result in a WCH value of 10 feet if the TCH over the beginning of the full strength runway pavement suitable for landing meets table 2-3 TCH requirements.

2.6.2 Category II and III TCH Requirements.

2.6.2 a. **Standard.** The commissioned TCH shall be between 50 and 60 feet with the optimum being 55 feet.

2.6.2 b. **Deviations from the Standard.** Any deviation must be formally approved by a Flight Standards waiver as outlined in Order 8260.19 or by the appropriate military authority.

2.6.2 c. **Temporary Exemption Clause.** Paragraph 4.0 may be applied to a published PA system where the TCH is within the allowable limits in table 2-3. If the new flight inspection derived TCH is within 3 feet of the published TCH but not within the limits of table 2-3, operations may continue without waiver action for up to 365 days from the date the order is applied.

2.6.2 c. (1) **If aircraft in height group 4** have not been excluded from conducting Category II or III operations on that runway, a TCH lower than 50 feet is not permitted unless the achieved ILS reference datum height (ARDH) has averaged 50 feet or higher.

2.6.2 c. (2) **After 365 days,** a flight procedures waiver must have been approved, the situation corrected, or Category II and III operations canceled.

2.6.2 c. (3) **Flight Standards Service** or the appropriate military authority can authorize further deviation or immediately rescind this temporary exemption.

Table 2-2C. Threshold Crossing Height Upper Limits for Allowing Visibility Credit for Lights

HAT (Feet)	GLIDEPATH ANGLE (Degrees)	TCH UPPER LIMIT (Feet)
200	3.00 - 3.20	75
	3.21 - 3.30	70
	3.31 - 3.40	66
	3.41 - 3.50	63
	3.51 - 3.60	59
	3.61 - 3.70	55
	3.71 - 3.80	50
	3.81 - 3.90	47
	3.91 - 4.00	43
	4.01 - 4.10	39
	4.11 - 4.20	35
250	3.00 - 4.10	75
	4.11 - 4.20	71
	4.21 - 4.30	67
	4.31 - 4.40	62
	4.41 - 4.50	58
	4.51 - 4.60	54
	4.61 - 4.70	50
	4.71 - 4.80	45
	4.81 - 4.90	41
	4.91 - 5.00	37
270	3.00 - 4.40	75
	4.41 - 4.50	73
	4.51 - 4.60	68
	4.61 - 4.70	64
	4.71 - 4.80	59
	4.81 - 4.90	55
	4.91 - 5.00	51

HAT (Feet)	GLIDEPATH ANGLE (Degrees)	TCH UPPER LIMIT (Feet)
300	3.00 - 4.90	75
	4.91 - 5.00	71
	5.01 - 5.10	66
	5.11 - 5.20	61
	5.21 - 5.30	56
	5.31 - 5.40	52
	5.41 - 5.50	48
	5.51 - 5.60	43
	5.61 - 5.70	39
350	3.00 - 5.60	75
	5.61 - 5.70	70
	5.71 - 5.80	65
	5.81 - 5.90	60
	5.91 - 6.00	55
	6.01 - 6.10	50
	6.11 - 6.20	45
	6.21 - 6.30	40
	6.31 - 6.40	35

2.6.3 Required TCH Values.

Publish a note indicating VGSI not coincident with the procedure GPA when the VGSI angle is more than 0.2 ° from the GPA, or when the VGSI TCH is more than 3 feet from the procedure TCH.

Table 2-3. TCH Requirements

Representative Aircraft Type	Approximate Glidepath to Wheel Height	Recommended TCH ± 5 Feet	Remarks
HEIGHT GROUP 1 General Aviation, Small Commuters, Corporate Turbojets, T-37, T-38, C-12, C-20, C-21, T-1, Fighter Jets, UC-35, T-3, T-6	10 Feet or less	40 Feet	Many runways less than 6,000 feet long with reduced widths and/or restricted weight bearing which would normally prohibit landings by larger aircraft.
HEIGHT GROUP 2 F-28, CV-340/440/580, B-737, C-9, DC-9, C-130, T-43, B-2, S-3	15 Feet	45 Feet	Regional airport with limited air carrier service.
HEIGHT GROUP 3 B-727/707/720/757, B-52, C-135, C-141, C-17, E-3, P-3, E-8, C-32	20 Feet	50 Feet	Primary runways not normally used by aircraft with ILS glidepath-to-wheel heights exceeding 20 feet.
HEIGHT GROUP 4 B-747/767/777, L-1011, DC-10, A-300, B-1, KC-10, E-4, C-5, VC-25	25 Feet	55 Feet	Most primary runways at major airports.

NOTES:
1. To determine the minimum allowable TCH, add 20 feet to the glidepath-to-wheel height.
2. To determine the maximum allowable TCH, add 50 feet to the glidepath-to-wheel height (PA not to exceed 60 ft.).
3. Publish a note indicating VGSI not coincident with the procedure GPA when the VGSI angle is more than 0.2° from the GPA, or when the VGSI TCH is more than 3 feet from the procedure TCH.

2.7 GROUND POINT OF INTERCEPT (GPI).

Calculate GPI distance using the following formula:

$$GPI = \frac{TCH}{\tan(GPA)}$$

2.8 DETERMINING FPAP COORDINATES. [RNAV Only]

The geographic relationship between the LTP and the FPAP determines the final approach ground track. Geodetically calculate the latitude and longitude of the FPAP using the LTP as a starting point, the desired final approach course

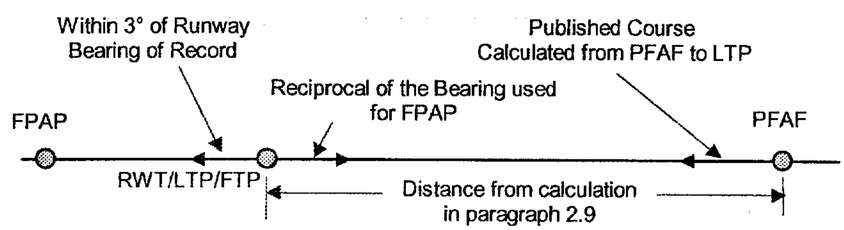
(OPTIMUM course is the runway bearing) as a forward azimuth value, and an appropriate distance. If an ILS or MLS serves the runway, the appropriate distance in feet is the distance from the LTP to the localizer antenna minus 1,000 feet, or the distance from the LTP to the DER, whichever is greater. Apply table 2-4 to determine the appropriate distance for runways not served by an ILS or MLS.

Table 2-4. Runways not served by an ILS or MLS

Runway Length	FPAP Distance from LTP	Splay	± Width
≤ 9,023'	9,023'	2.0°	350'
> 9,023' and ≤ 12,366'	to DER	$\text{ArcTan}\left(\frac{350}{\text{RWY length}+1000}\right)$	350'
> 12,366 and ≤ 16,185'	to DER	1.5°	$\tan(1.5)(\text{RWY length}+1{,}000))$
> 16,185' (AFS or Appropriate Military Agency Approval)	to DER or as specified by approving agency	1.5°	$\tan(1.5)(\text{RWY length}+1{,}000))$

2.9 DETERMINING PFAF/FAF COORDINATES. See figure 2-4.

Figure 2-4. Determining PFAF Location



Geodetically calculate the latitude and longitude of the PFAF using the horizontal distance (D-GPI) from the LTP or FTP to the point the glidepath intercepts the intermediate segment altitude. Determine D using the following formulas: {step 2 formula includes earth curvature}

Step 1: Formula: $z = A - F$

Example: $2{,}100 - 562.30 = 1{,}537.70$

Step 2: Formula: $D = 364{,}609\left(90 - \theta - \sin^{-1}\left(\frac{20{,}890{,}537\sin(90+\theta)}{z + 20{,}890{,}537}\right)\right)$

Example: $D = 364{,}609\left(90 - 3 - \sin^{-1}\left(\frac{20{,}892{,}537\sin(90+3)}{1{,}537.7 + 20{,}890{,}537}\right)\right)$

$D = 28{,}956.03$

Where: A = FAF Altitude in feet (example 2,100)
F = LTP elevation in feet (example 562.30)
θ = Glidepath angle (example 3.00°)

2.9.1 Distance Measuring Equipment (DME).

When installed with ILS, DME may be used in lieu of the outer marker. When a unique requirement exists, DME information derived from a separate facility, as specified in Volume 1, paragraph 282, may also be used to provide ARC initial approaches, a FAF for back course (BC) approaches, or as a substitute for the outer marker. When used as a substitute for the outer marker, the fix displacement error shall NOT exceed ± 1/2 NM and the angular divergence of the signal sources shall NOT exceed 6° (DOD 23°).

2.10 COMMON FIXES. [RNAV Only]

Design all procedures published on the same chart to use the same sequence of charted fixes.

2.11 CLEAR AREAS AND OBSTACLE FREE ZONES (OFZ).

Airports division is responsible for maintaining obstruction requirements in AC 150/5300-13, Airport Design. Appropriate military directives apply at military installations. For the purpose of this order, there are two OFZ's that apply: the runway OFZ and the inner approach OFZ. The runway OFZ parallels the length of the runway and extends 200 feet beyond the runway threshold. The inner OFZ overlies the approach light system from a point 200 feet from the threshold to a point 200 feet beyond the last approach light. If approach lights are not installed or not planned, the inner approach OFZ does not apply. When obstacles penetrate either the runway or approach OFZ, visibility credit for lights is not authorized, and the lowest authorized HAT and visibility values are (USAF NA):

- For GPA ≤ 4.2°: 250-¾
- For GPA > 4.2°: 350-1

NOTE: Application of Volume 1, paragraph 251 may require a higher minimum visibility value.

2.12 GLIDEPATH QUALIFICATION SURFACE (GQS)

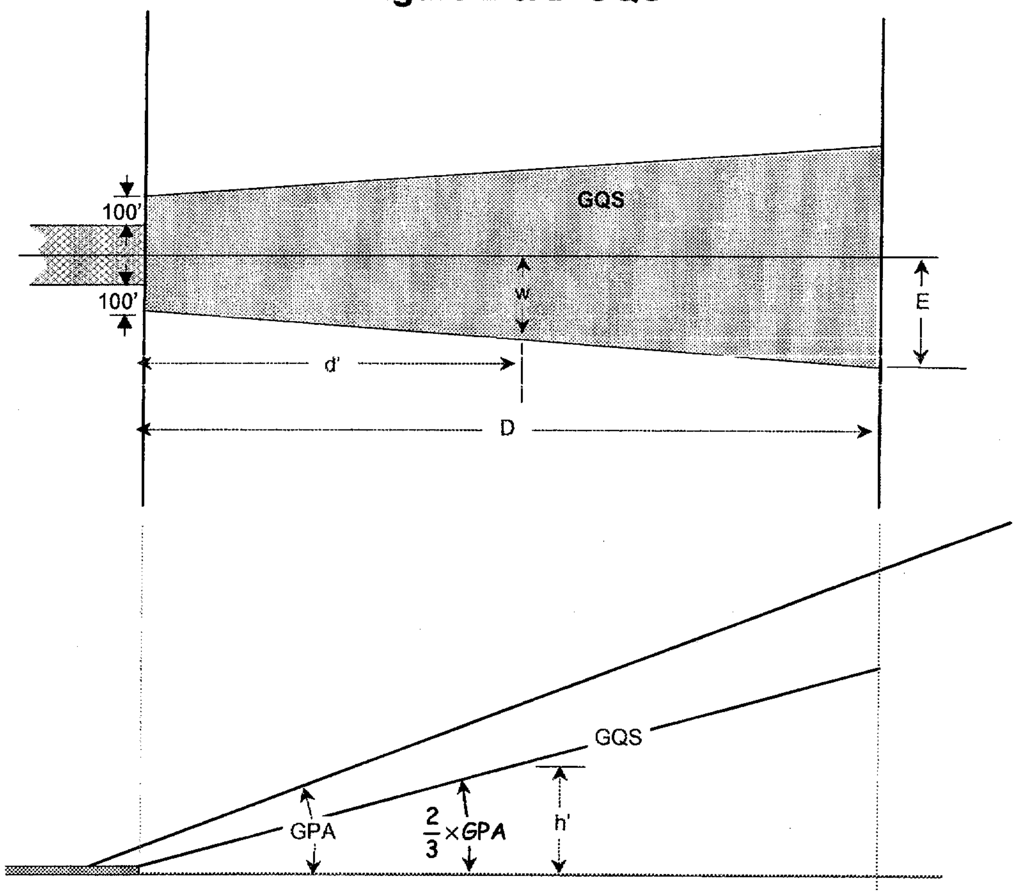
The GQS extends from the runway threshold along the runway centerline extended to the DA point. It limits the height of obstructions between DA and RWT. When obstructions exceed the height of the GQS, an approach procedure with positive vertical guidance (ILS, MLS, TLS, GLS, VNAV, etc.) is not authorized (see figures 2-5A and 2-5B).

2.12.1 Area.

2.12.1 a. **Length**. The GQS extends from the runway threshold to the DA point.

2.12.1 b. **Width**. The GQS originates 100 feet from the runway edge at RWT.

Figure 2-5A. GQS



Calculate the half-width of the GQS (E) from the runway centerline extended at the DA point using the following formula:

$$E = 0.036(D - 200) + 400$$

Where: D=the distance (ft) measured along RCL extended from RWT to the DA point
E=GQS half-width (ft) at DA

2.12.1 c. **If the course is offset** from the runway centerline more than 3°, expand the GQS area on the side of the offset as follows referring to figure 2-5B:

STEP 1. Construct line BC. Locate point "B" on the runway centerline extended perpendicular to course at the DA point. Calculate the half-width (E) of the GQS for the distance from point "B" to the RWT. Locate point "C" perpendicular to the course distance "E" from the course line. Connect points "B" and "C."

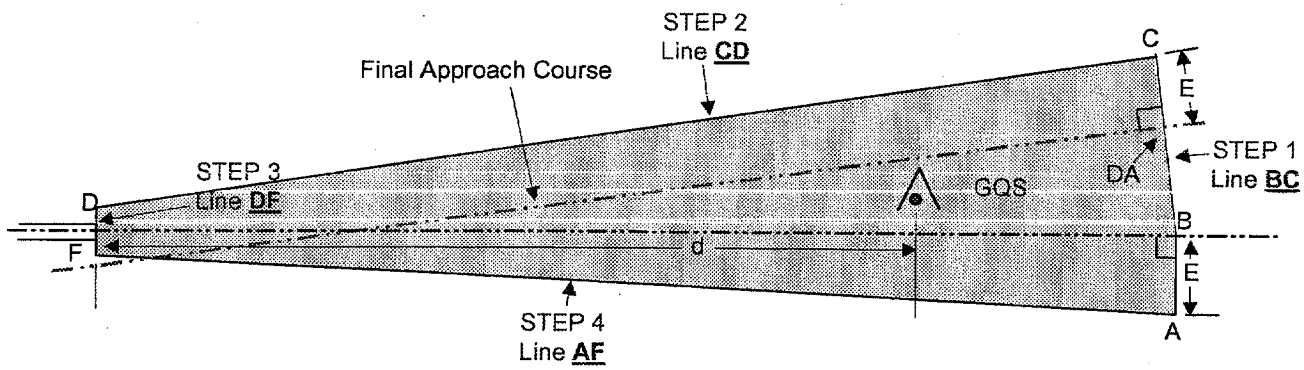
STEP 2. Construct line <u>CD</u>. Locate point "D" 100 feet from the edge of the runway perpendicular to the LTP. Draw a line connecting point "C" to point "D."

STEP 3. Construct line <u>DF</u>. Locate point "F" 100 feet from the edge of the runway perpendicular to the LTP. Draw a line connecting point "D" to point "F."

STEP 4. Construct line <u>AF</u>. Locate point "A" distance "E" from point "B" perpendicular to the runway centerline extended. Connect point "A" to point "F."

STEP 5. Construct line <u>AB</u>. Connect point "A" to point "B."

Figure 2.5B. Final Approach Course Offset >3°



Calculate the half-width of the GQS at any distance "d" from RWT using the following formula:

$$w = \left(\frac{E-k}{D}d\right) + k$$

Where: D = distance (ft) from RWT to the DA point
d = desired distance (ft) from RWT
w = GQS half-width at distance d
E = GQS half-width at DA from step 1 above

$$k = \frac{\text{RWT width}}{2} + 100$$

2.12.1 **d. OCS**. Obstructions shall not penetrate the GQS. Calculate the height of the GQS above ASBL at any distance "d" measured from RWT along RCL extended to a point abeam the obstruction (see figure 2-5B) using the following formula:

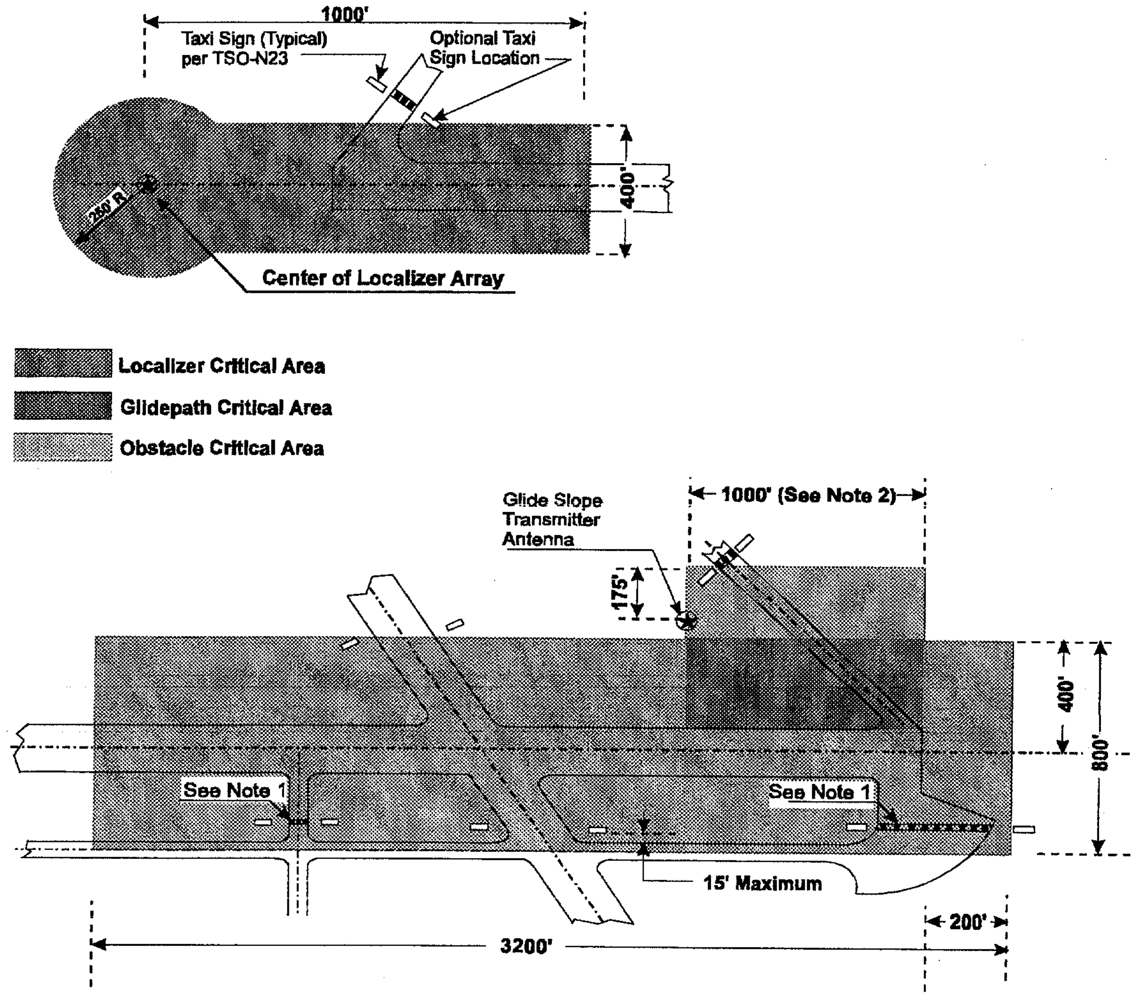
$$h = \tan\left(\frac{2\theta}{3}\right)d$$

Where d = distance from RWT (ft)
θ = glidepath angle

2.13 ILS/MLS Critical Areas.

Figure 2-6 identifies the critical area that must be clear during IFR ILS/MLS approach operations.

Figure 2-6. Category II Critical Areas

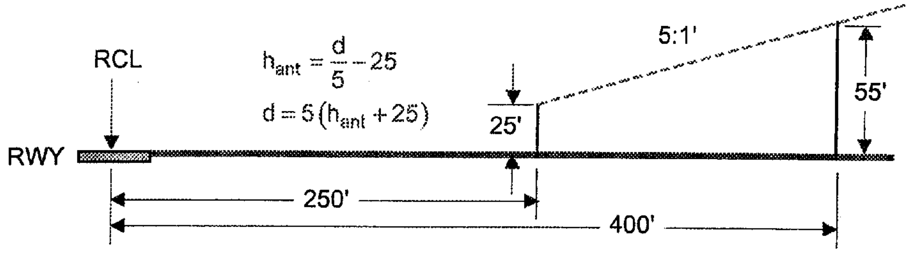


NOTES: 1. Location of hold lines when operations are permitted on a 400-foot parallel taxiway.
2. Or to the end of the runway, whichever is greater.

2.14 ILS ANTENNA MAST HEIGHT LIMITATIONS FOR OBSTACLE CLEARANCE.

The standard for locating the ILS antenna mast or monitor is a MINIMUM distance of 400 feet from the runway measured perpendicular to RCL. The antenna mast should not exceed 55 feet in height above the elevation of the runway centerline nearest it (see figure 2-7). At locations where it is not feasible for technical or economic reasons to meet this standard, the height and location of the antenna is restricted according to the following formula:

Figure 2-7. ILS Antenna Mast Limitations



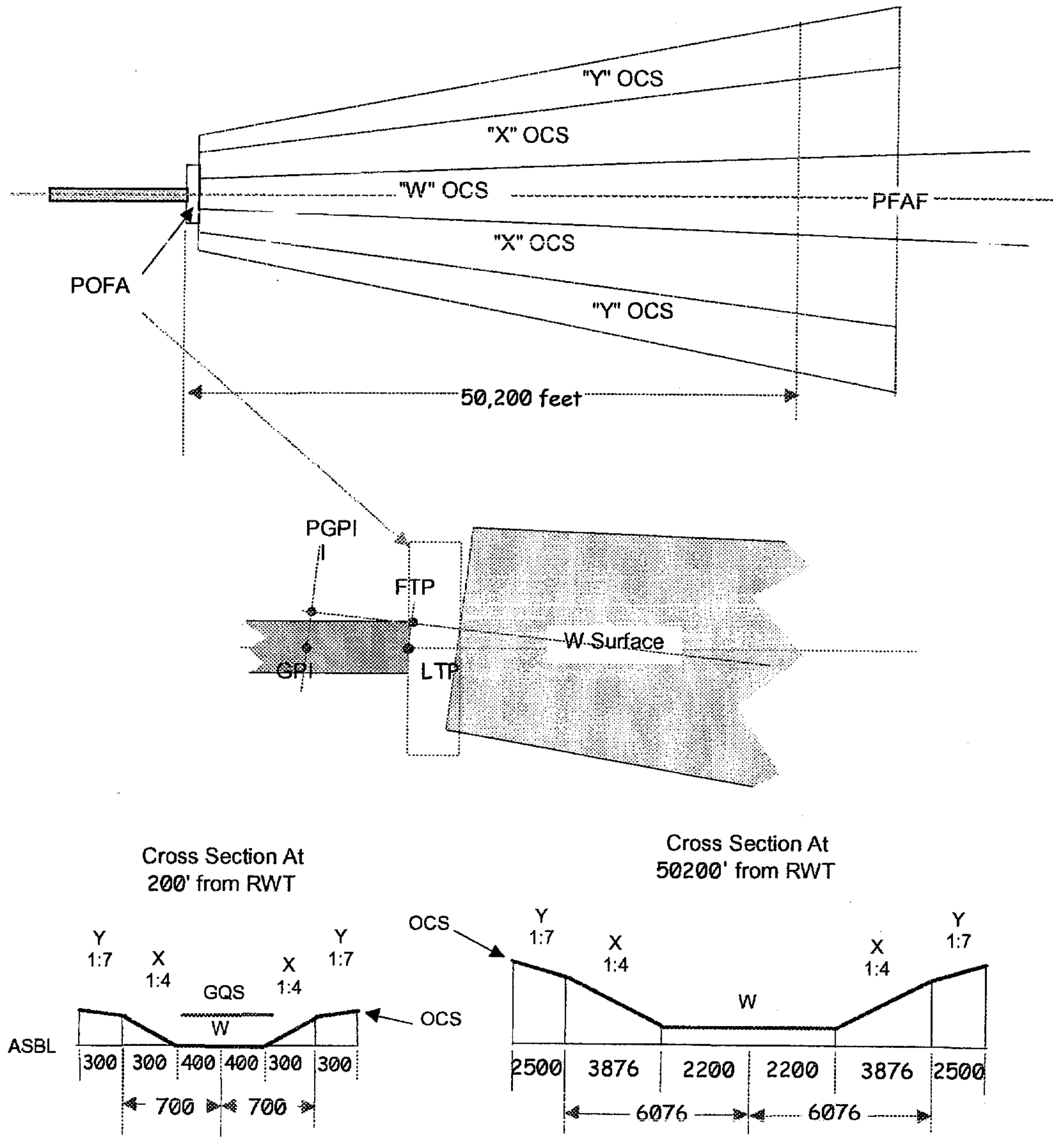
Where h_{ant} = MAXIMUM height of mast above RCL abeam mast
d = perpendicular distance from RCL (250' MINIMUM)

CHAPTER 3. PRECISION FINAL AND MISSED APPROACH SEGMENTS

3.0 FINAL SEGMENT.

The area originates 200 feet from LTP or FTP and ends at the PFAF (see figure 3-1). The primary area consists of the "W" and "X" OCS, and the secondary area consists of the "Y" OCS.

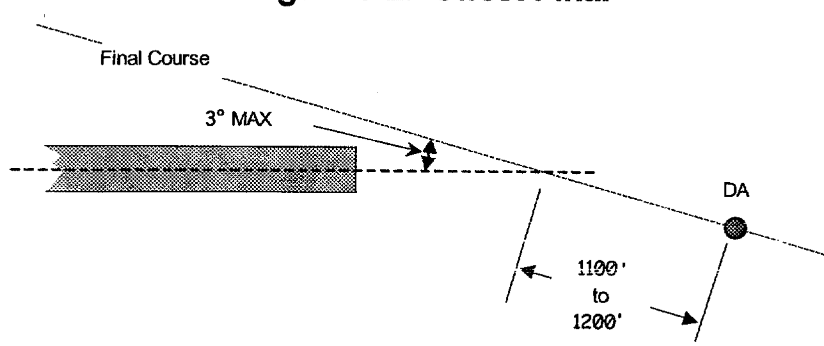
Figure 3-1. Precision Obstacle Clearance Areas



3.1 ALIGNMENT.

The final course is normally aligned with the runway centerline extended (± 0.03°) through the LTP/RWT (± 5 feet). Where a unique operational requirement indicates a need for an offset course, it may be approved provided the offset does not exceed 3°. Where the course is not aligned with the RCL, the MINIMUM HAT is 250 feet, and MINIMUM RVR is 2,400 feet. Additionally, the course must intersect the runway centerline at a point 1,100 to 1,200 feet toward the LTP/RWT from the DA point (see figure 3-2).

Figure 3-2. Offset Final



3.2 OCS SLOPE(S).

In this document, slopes are expressed as rise over run; e.g., 1:34. Determine the OCS slope associated with a specific GPA using the following formula:

$$S = \frac{102}{GPA} \qquad \text{example: } \frac{102}{3} = 34$$

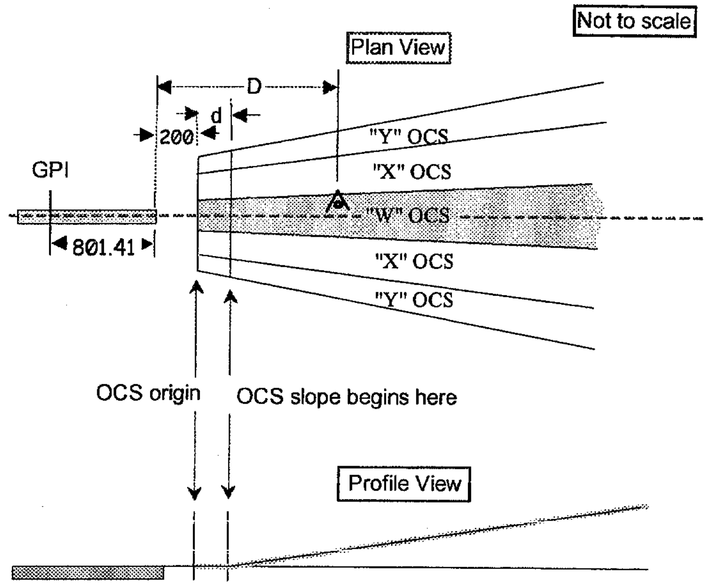
3.2.1 Origin.

The OCS begins at 200 feet from LTP or FTP, measured along course centerline and extends to the PFAF. The rising slope normally begins at the OCS origin. However, when the GPI to RWT distance is less than 954 feet, the slope is zero from its origin to distance 'd' from the origin. The slope associated with the glidepath begins at this point (see figure 3-3). Use the following formula to determine distance 'd':

$$d = 954 - GPI \qquad \text{Example: } 954 - 801.41 = 152.59$$

Where $GPI = 801.41$

Figure 3-3. OCS Slope Origin When GPI <954'



3.2.2 Revising GPA For OCS Penetrations.

Raising the glidepath angle may eliminate OCS penetrations. To determine the revised minimum glidepath angle, use the following formula:

$$\frac{102\left[\frac{D-(200+d)}{s}+p\right]}{D-(200+d)} = \text{Revised Angle} \qquad \text{Example: } \frac{102\left[\frac{2200-(200+0)}{34}+2.18\right]}{2200-(200+0)} = 3.12°*$$

Where D = distance (ft) from RWT
d = d from paragraph 3.2.1 for GPI < 954', 0 for GPI 954' or greater
s = "W" surface slope
p = penetration in feet

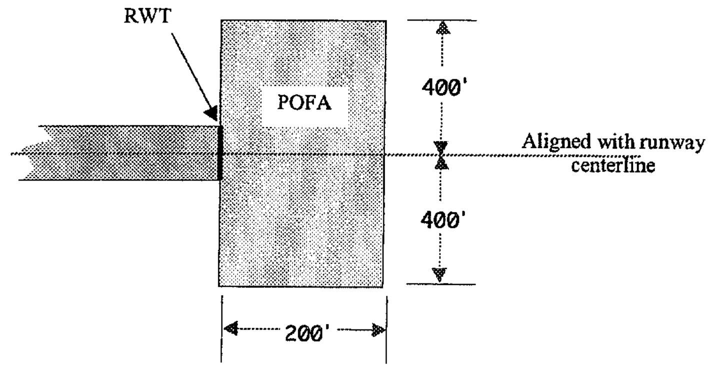
Where D = 2200
d = 0
s = 34
p = 2.18

*Actual answer is 3.1118°. Always round to the next higher hundredth (0.01) degree. This prevents rounding errors in amount of penetration causing miniscule penetration values using the revised angle.

3.3 PRECISION OBJECT FREE AREA (POFA).

The POFA is an area centered on the runway centerline extended, beginning at the RWT, 200 feet long, and ± 400 feet wide. The airport sponsor is responsible for maintaining POFA obstruction requirements in AC 150/5300-13 (see figure 3-4). If the POFA is not clear, the minimum HAT/visibility is 250 feet/ 3/4 SM.

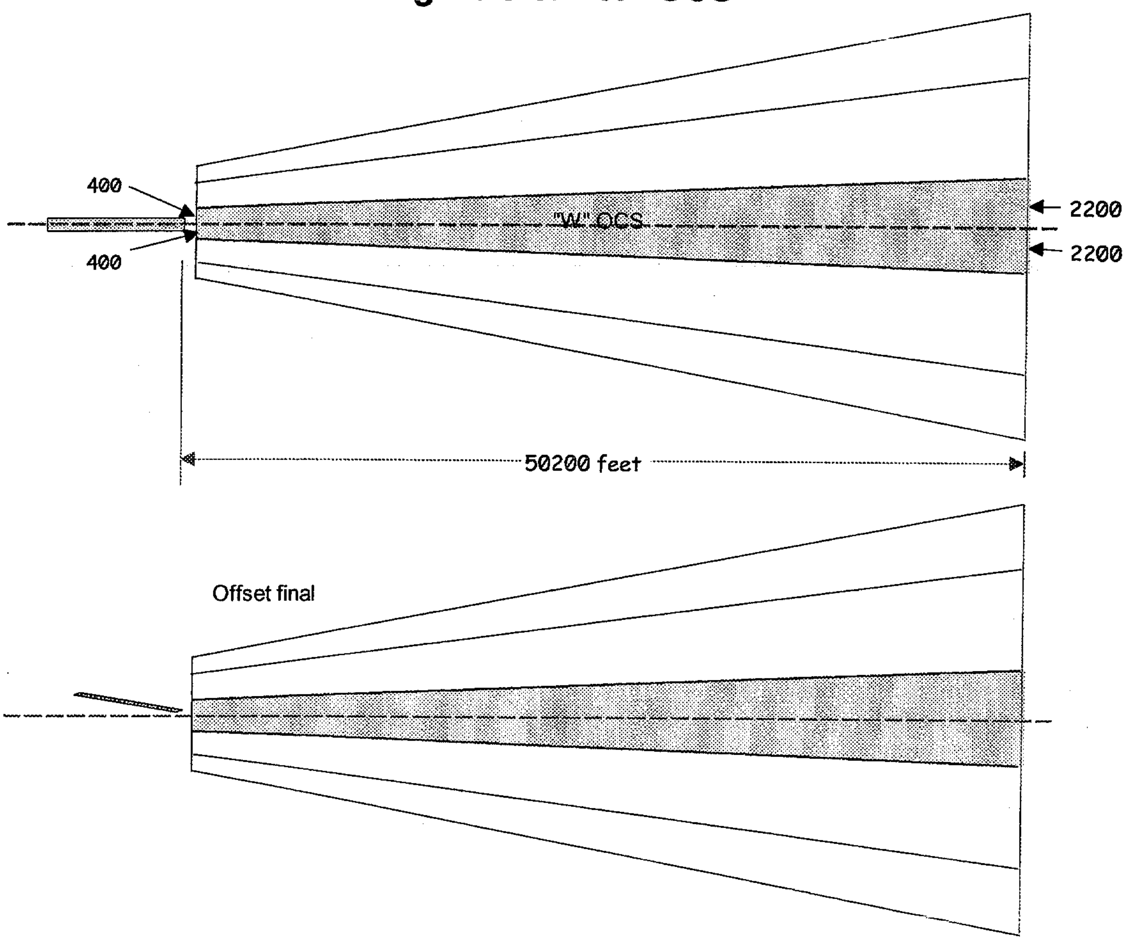
Figure 3-4. POFA



Scale exaggerated for emphasis

3.4 **"W" OCS.** See figure 3-5.

Figure 3-5. "W" OCS



3.4.1 **Width.** The width is 400 feet either side of course at the beginning, and expands uniformly to 2,200 feet either side of course 50,200 feet from LTP or FTP, as defined by the formula:

$$D_W = 0.036(D-200)+400$$

Where D = the distance in feet from LTP or FTP.
D_W = Perpendicular distance in feet from course centerline to "W" surface outer boundary.

3.4.2 **Height.** The height (Z_W) of the "W" OCS above ASBL is defined by the formula:

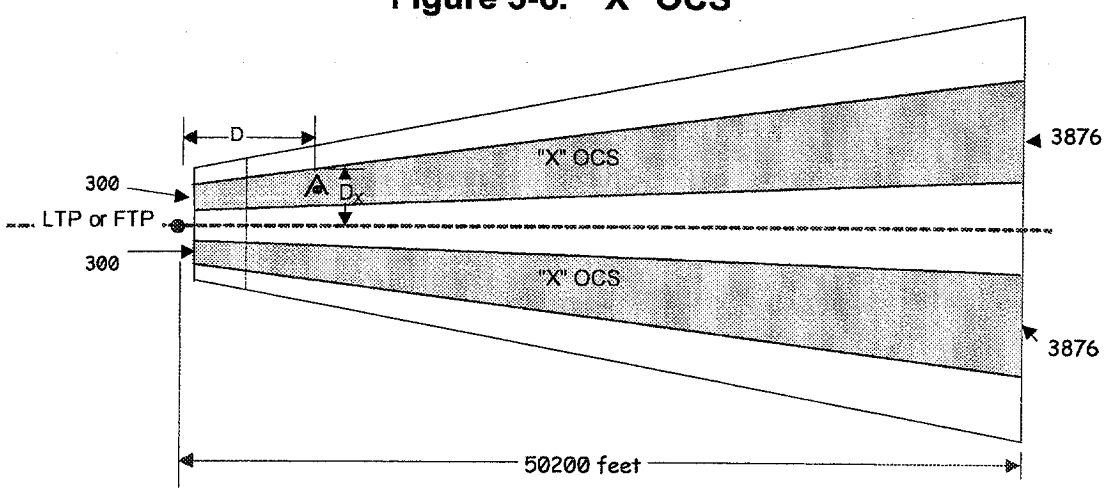
$$Z_W = \frac{D-(200+d)}{S}$$

Where D = the distance in feet from RWT
d = d from paragraph 3.2.1 for GPI < 954', 0 for GPI 954' or greater
S = "W" surface slope

3.4.3 **"W" OCS Penetrations.** Lowest minimums are achieved when the "W" surface is clear. If the surface is penetrated by an existing obstacle, adjust obstruction height, raise the GPA (see paragraph 3.2.2), or displace the RWT to eliminate the penetration. If the penetration cannot be eliminated, adjust the DA (see paragraph 3.8).

3.5 **"X" OCS.** See figure 3-6.

Figure 3-6. "X" OCS



3.5.1 **Width.** The perpendicular distance (D_X) from the course to the outer boundary of the "X" OCS is defined by the formula:

$$D_X = 0.10752(D-200)+700$$

Where D=distance (ft) from LTP or FTP

3.5.2 **Height.** The "X" OCS begins at the height of the "W" surface at distance "D" from LTP or FTP, and rises at a slope of 1:4 in a direction perpendicular to the final approach course. Determine the height (Z_X) above ASBL for a specific location of the "X" OCS using the following formula:

$$Z_X = \underbrace{\frac{D-(200+d)}{S}}_{\text{Height of "W" Sfc}} + \underbrace{\frac{D_O - D_W}{4}}_{\text{Rise of "X" Sfc}}$$

Where D = the distance in feet from LTP or FTP,

d = d from paragraph 3.2.1 for GPI < 954', 0 for GPI 954' or greater

D_O = the perpendicular distance in feet between course centerline and a specific point in the "X" surface

D_W = the perpendicular distance between course centerline and the "W" surface boundary.

S = Slope associated with GPA $\left[\frac{102}{GPA}\right]$

3.5.3 **"X" OCS Penetrations.** Lowest minimums can be achieved when the "X" OCS is clear. To eliminate, avoid, or mitigate a penetration, take one of the following actions listed in the order of preference.

3.5.3 a. **Remove or adjust** the obstruction location and/or height.

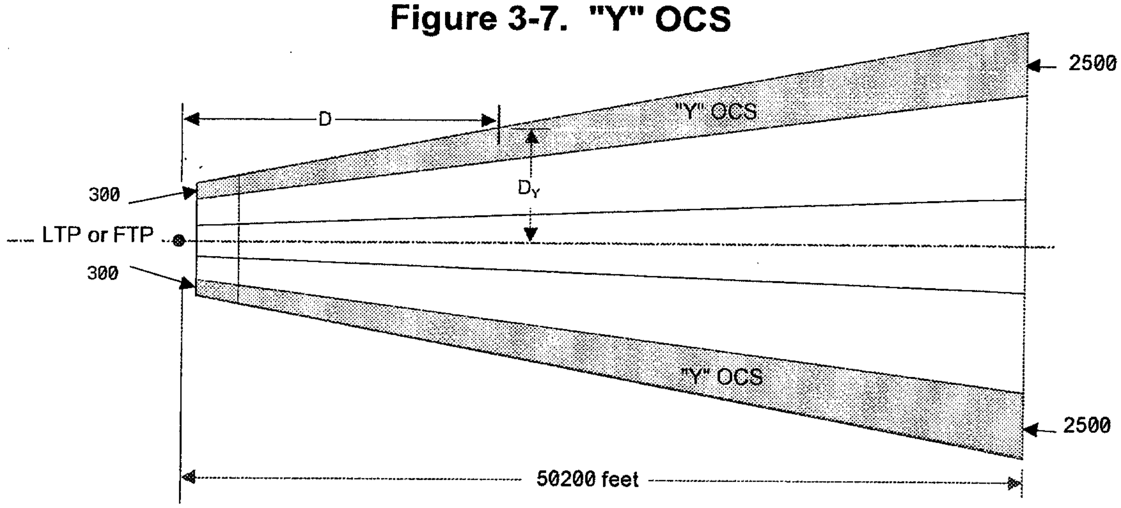
3.5.3 b. **Displace the RWT.**

3.5.3 c **Raise the GPA** (see paragraph 3.2.2) within the limits of table 2-2A.

3.5.3 d. **Adjust DA** (for existing obstacles only). (See paragraph 3.8).

3.6 **"Y" OCS.** See figure 3-7.

Figure 3-7. "Y" OCS



3.6.1 **Width.** The perpendicular distance (D_Y) from the runway centerline extended to the outer boundary of the "Y" OCS is defined by the formula:

$$D_Y = 0.15152(D-200)+1000$$

Where D=distance (ft) from LTP or FTP

3.6.2 **Height.** The "Y" OCS begins at the height of the "X" surface at distance "D" from LTP or FTP, and rises at a slope of 1:7 in a direction perpendicular to the final approach course. The height (Z_Y) of the "Y" surface above ASBL is defined by the formula:

$$\begin{array}{cccc} & \text{Height of} & \text{Rise of} & \text{Rise of} \\ & \text{"W" Sfc} & \text{"X" Sfc} & \text{"Y" Sfc} \\ D_Y = & \frac{D-(200+d)}{S} + & \frac{D_X - D_W}{4} + & \frac{D_O - D_X}{7} \end{array}$$

Where D = the distance in feet from the LTP or FTP,
d = d from paragraph 3.2.1 for GPI < 954′, 0 for GPI 954′ or greater
D_x = the perpendicular distance in feet between course centerline and "X" surface outer boundary,
D_0 = perpendicular distance in feet between course centerline and an obstruction in the "Y" surface.

3.6.3 **"Y" OCS Penetrations.** Lowest minimums can be achieved when the "Y" OCS is clear. When the OCS is penetrated, remove the obstruction or reduce its height to clear the OCS. If this is not possible, a subjective evaluation is necessary. Consider the obstruction's physical nature, the amount of penetration, obstruction location with respect to the "X" surface boundary, and density of the obstruction environment to determine if the procedure requires adjustment. (**USAF**: Adjustment mandatory if obstruction cannot be removed, height adjust, or options in paragraphs 3.6.3 b-d cannot be accomplished.) If an adjustment is required, take the appropriate actions from the following list:

3.6.3 a. **Adjust DA** for existing obstacles (see paragraph 3.8).

3.6.3 b. **Displace threshold**.

3.6.3 c. **Offset final course**.

3.6.3 d. **Raise GPA** (see paragraph 3.2.2).

3.6.3 e. **If an adjustment is not required**, CHART the obstruction.

3.7 **DECISION ALTITUDE (DA) AND HEIGHT ABOVE TOUCHDOWN (HAT).**

The DA value may be derived from the HAT. The MINIMUM HAT for Category I operations is 200 feet. Calculate the DA using the formula:

$$DA = HAT + TDZE$$

3.8 **ADJUSTMENT OF DA FOR FINAL APPROACH OCS PENETRATIONS.** See figure 3-8.

The distance from GPI to the DA may be increased to ensure DA occurs at a height above ASBL providing sufficient obstruction clearance. This adjustment is available for existing obstacles only. Proposed obstructions shall not penetrate the OCS.

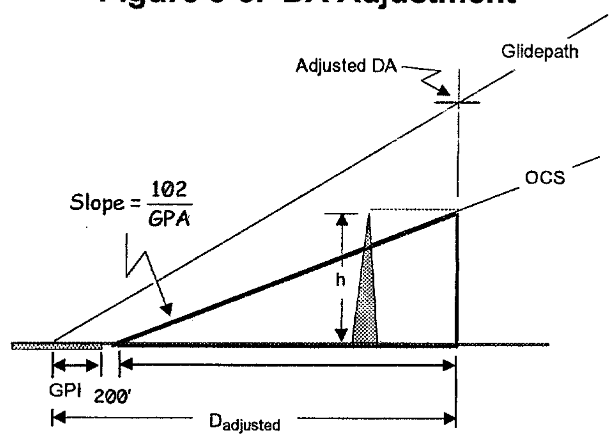
3.8.1 **GPI Distance.** Determine the distance from LTP to the adjusted DA point using the formula:

$$D_{adjusted} = \frac{102h}{GPA} + (200 + d)$$

Where $D_{adjusted}$ =adjusted distance (ft) from LTP to DA
D=d from paragraph 3.2.1 for GPI<954', 0 for GPI ≥954'
H=obstacle height (ft) above ASBL

NOTE: If obstacle is in the "X" surface, subtract "X" surface rise from h. If obstacle is in the "Y" surface, subtract "X" and "Y" surface rise from h.

Figure 3-8. DA Adjustment



3.8.2 **Calculate the adjusted DA and HAT:**

$$DA = \tan\left(\left[\frac{102h}{GPA} + (200 + d)\right] + \frac{TCH}{\tan(GPA)}\right) + LTP_{elevation}$$

$$HAT = DA - TDZE$$

3.8.3 **Calculate the revised minimum HAT/maximum ROC** using the formula:

$$\text{Min Hat and Max ROC} = \frac{GPA}{3}250$$

3.8.4 **Compare HAT and Minimum HAT.** Publish the higher of the two values.

3.8.5 **Mark and Light**. Initiate action to mark and light obstruction(s) that would require DA adjustment when they are located between the DA and the LTP/FTP.

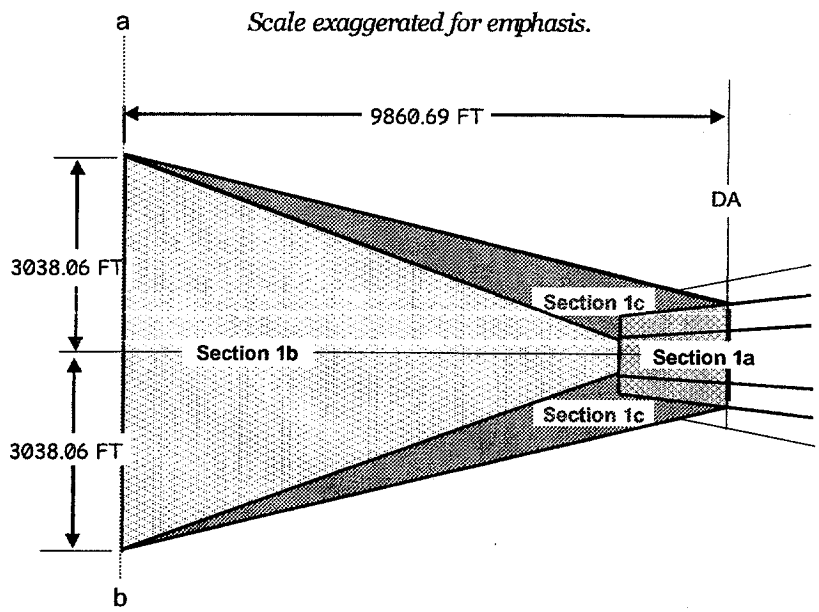
3.9 MISSED APPROACH.

The missed approach segment begins at DA and ends at the clearance limit. It is comprised of section 1 (initial climb) and section 2 (from end of section 1 to the clearance limit). Section 2 is constructed under criteria contained in Order 8260.44 for RNAV procedures. Section 2 beginning width is ± 0.5 NM.

The 40:1 OCS begins at the elevation of section 1b at centerline. The MA procedure is limited to two turn fixes (see figure 3-9A).

3.9.1 **Section 1.** Section 1 is aligned with the final approach course. It is comprised of 3 subsections, beginning at DA and extending 9860.69 feet.

Figure 3-9A. Missed Approach Sections 1a,b,c



3.9.1 **a. Section 1a.**

3.9.1 **a. (1) Area**. Section 1a begins at the DA point and overlies the final approach primary ("W" and "X" surfaces) OCS, extending 1,460 feet in the direction of the missed approach. This section is always aligned with the final approach course (see figures 3-9B and 3-9C).

3.9.1 **a. (2) OCS.** The height of the section 1a surface is equal to the underlying "W" or "X" surface as appropriate. If this section is penetrated, adjust DA per figure 3-9C to mediate the penetration.

Figure 3-9B . Section 1a

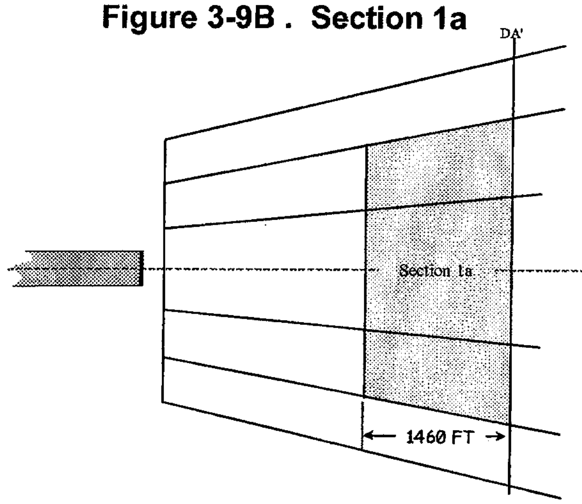
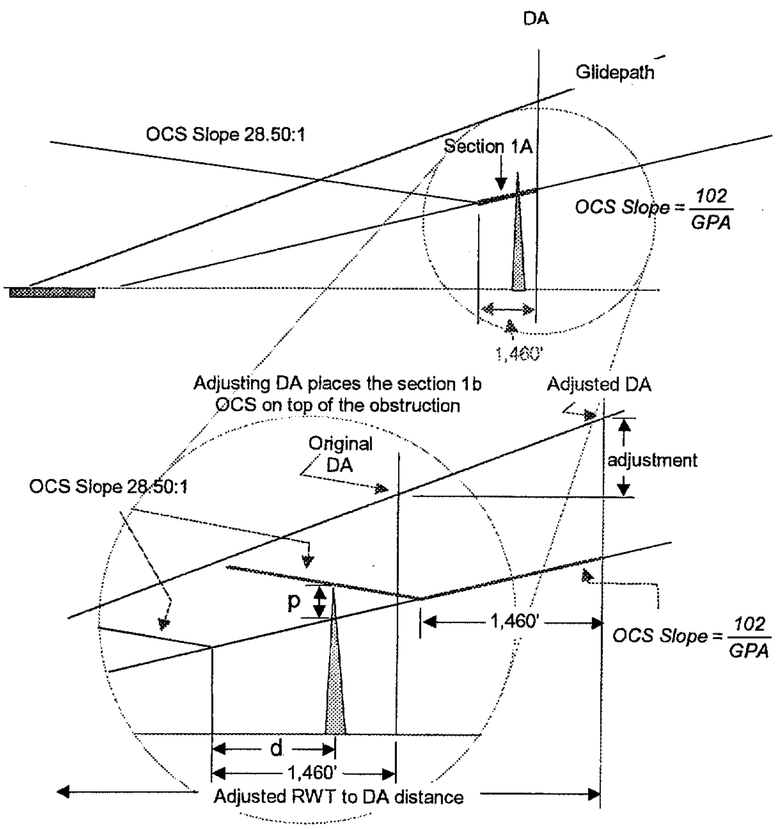


Figure 3-9C. Penetration of Section 1a OCS



$$d = x_O - (\text{RWT to DA Distance} - 1{,}460)$$

$$\text{adjustment} = \tan(\text{GPA}) \times \left[\left(\frac{p}{\frac{1}{28.50} + \frac{\text{GPA}}{102}}\right) + d\right]$$

$$\text{adjusted DA (MSL)} = \text{original DA} + \text{adjustment}$$

$$\text{adjusted RWT to DA Distance} = \frac{\text{Adjusted DA (MSL)} - (\text{RWT MSL Elevation} + \text{TCH})}{\tan(\text{GPA})}$$

where p = penetration (ft)
GPA = glidepath angle
x_O = distance from RWT to obstruction
d = distance (ft) from obstruction to point where the 28.50 : 1 OCS originates

3.9.1 b. Section 1b.

3.9.1 **b. (1) Area.** Section 1b begins at the end of section 1a, extends to a point 9860.69 feet from DA, and splays along the extended final course to a total width of 1 NM. This section is always aligned with the final approach course (see figures 3-9A, 3-9D).

3.9.1 **b. (2) OCS.** Section 1b OCS is a 1:28.5 inclined plane rising in the direction of the missed approach. The height of the beginning of section 1b is equal to the height of the "W" OCS at the end of section 1a (see figure 3-9D). Evaluate obstructions using the shortest distance of the obstruction from the end of section 1a. Adjust DA per figure 3-9E to mediate penetrations in this section.

Figure 3-9D. Section 1b

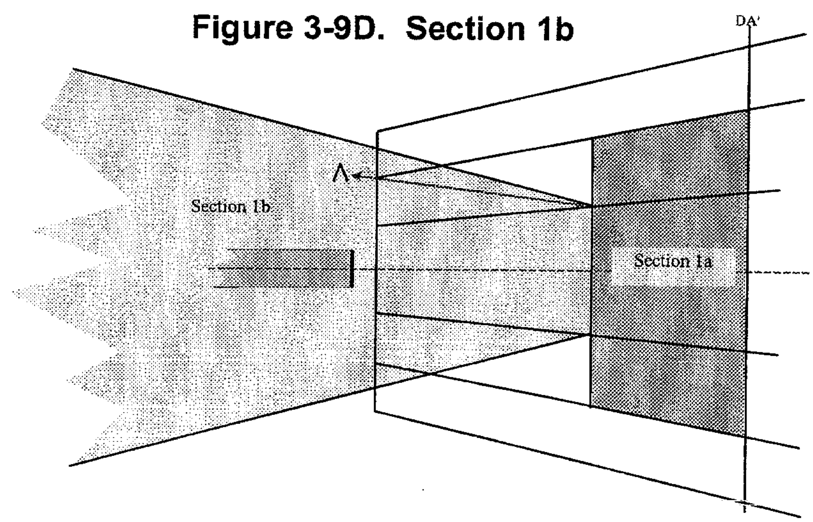
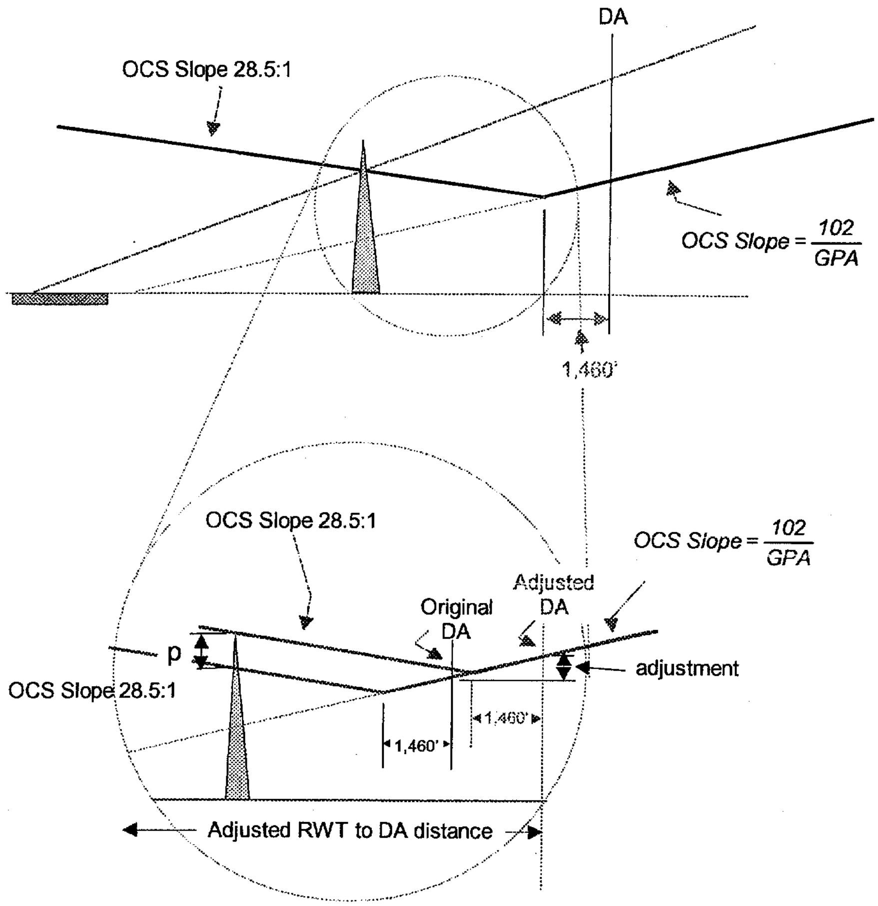


Figure 3-9E. Penetration of Section 1b OCS



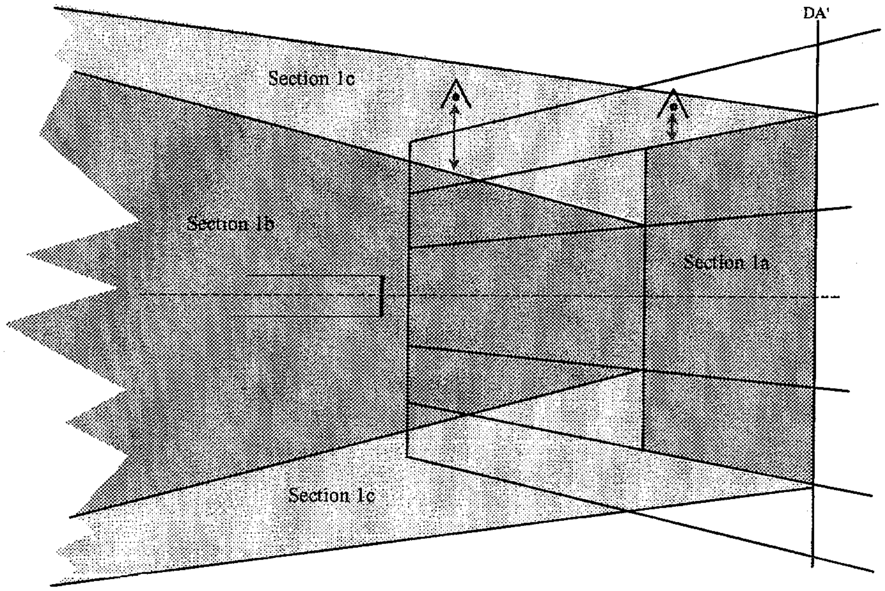
$$\text{adjustment} = \tan(\text{GPA}) \times \left(\frac{p}{\frac{1}{28.5} + \frac{\text{GPA}}{102}} \right)$$

$$\text{adjusted DA (MSL)} = \text{original DA} + \text{adjustment}$$

$$\text{adjusted RWT to DA Distance} = \frac{\text{adjusted DA (MSL)} - (\text{RWT MSL Elevation} + \text{TCH})}{\tan(\text{GPA})}$$

where p = penetration (ft)
GPA = glide path angle

Figure 3-9F. Section 1c



3.9.1 c. **Section 1c** (see figure 3-9F).

3.9.1 c. (1) **Area.** These are 1:7 secondary areas that begin at the DA point. These sections splay to a point on the edge and at the end of section 1b.

3.9.1 c. (2) **OCS.** An inclined plane starting at the DA point and sloping 1:7, perpendicular to the MA course. The inner boundaries originate at the elevation of the outer edges of the "W" surface at the beginning of section 1b. The outer boundaries originate at the elevation of the outer edges of the "X" surfaces at the DA point. These inner and outer boundaries converge at the end of section 1b (9860.69 feet from the DA point). Obstacles in section 1c, adjacent to the "X" surfaces, are evaluated with a 1:7 slope from the elevation of the outer boundaries of the "X" surfaces. Obstacles in section 1c, adjacent to section 1b, are evaluated using the 1:7 slope, beginning at the elevation at the outer edge of section 1b (see figures 3-9A and 3-9F). Reduce the obstruction height by the amount of 1:7 surface rise from the edge of section 1a or 1b (measured perpendicular to section 1 course). Then evaluate the obstruction as if it were in section 1a or 1b.

3.9.1 d. **Section 2. [RNAV Only]** Apply Order 8260.44 criteria in this section. Instead of the departure trapezoid originating at DER altitude at the DER, it originates at the elevation of the end of section 1b OCS at centerline, with a width of ± 0.5 NM (along the ab line). It ends at the plotted position of the clearance limit. The primary and secondary widths shall be the appropriate width from the distance flown. Establish a fix on the continuation of the final approach course at least 0.5 NM from the end of section 1 (ab line). If the fix is a fly-by turning waypoint, locate the fix at least DTA+0.5 NM from the ab line (see figures 3-10A and 3-10B). Use table 3-1 airspeeds to determine turn radii from Order 8260.44, table 2. Establish the outer boundary radius of a turning procedure based on the highest category aircraft authorized to use the approach.

Table 3-1

Category	*MA Altitude < 10,000' MSL*	*MA Altitude ≥ 10,000' MSL*
A, B	200 KIAS	200 KIAS
C, D, E	250 KIAS	310 KIAS

Figure 3-10A. Turning Missed Approach with Turning Fix at the Minimum Required Distance

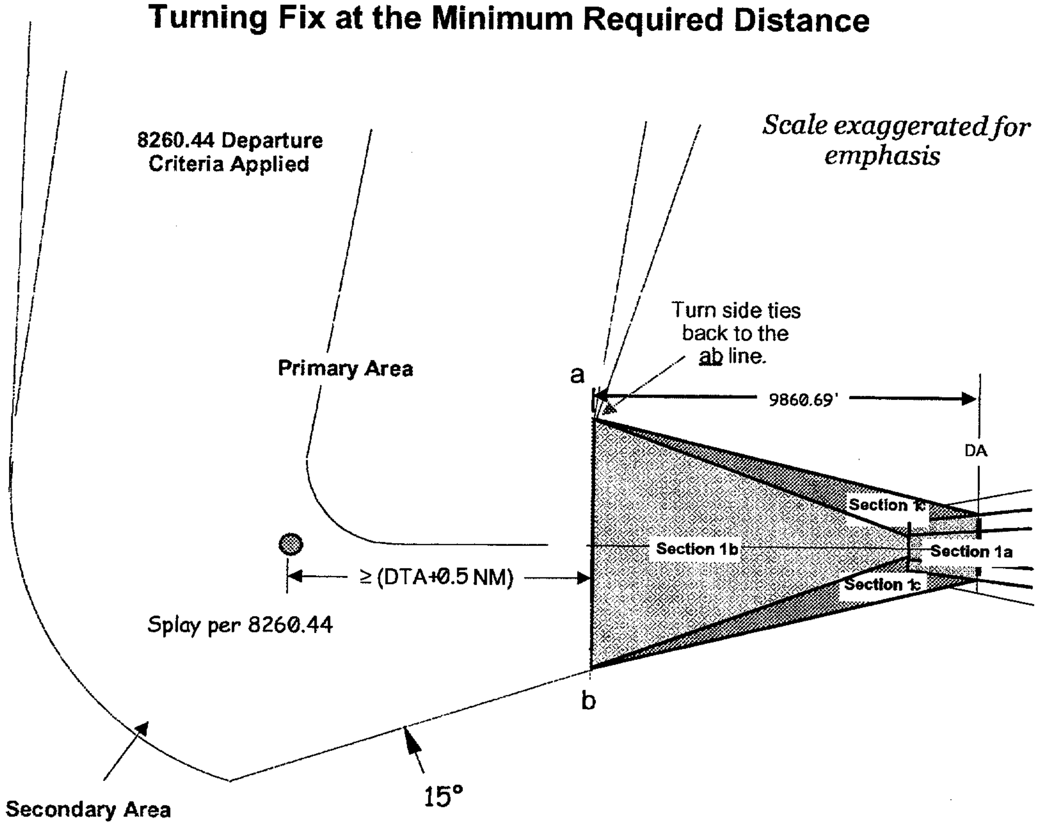
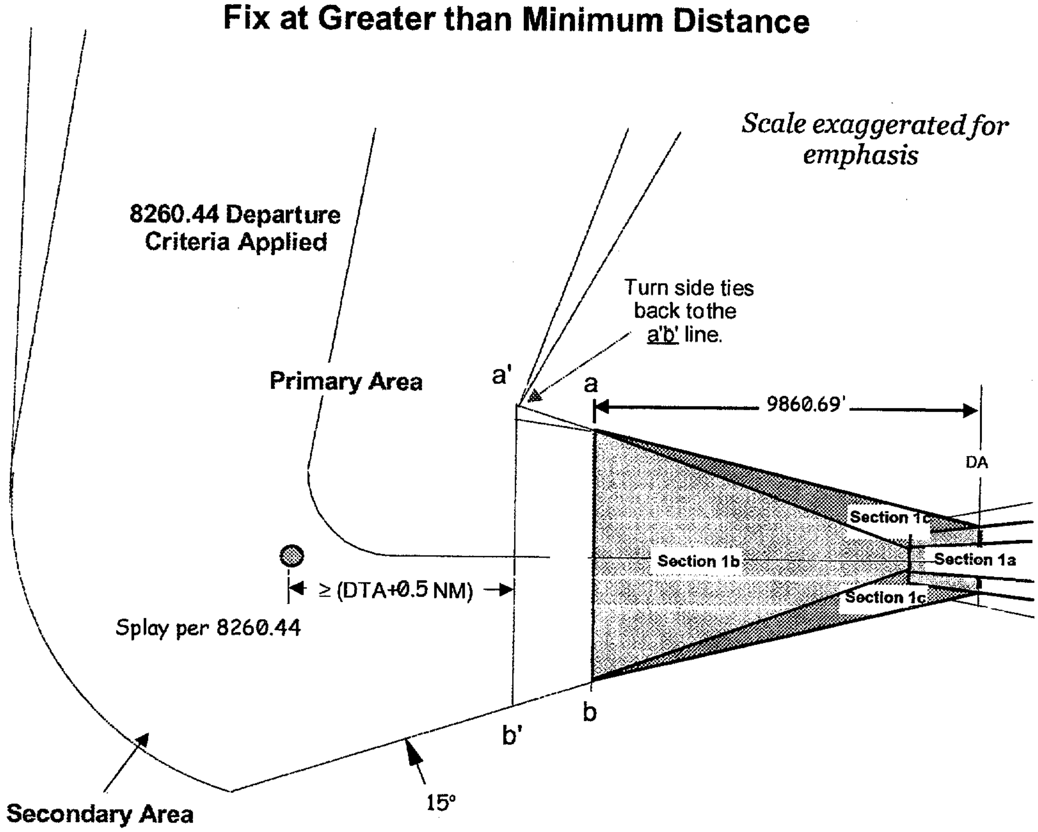


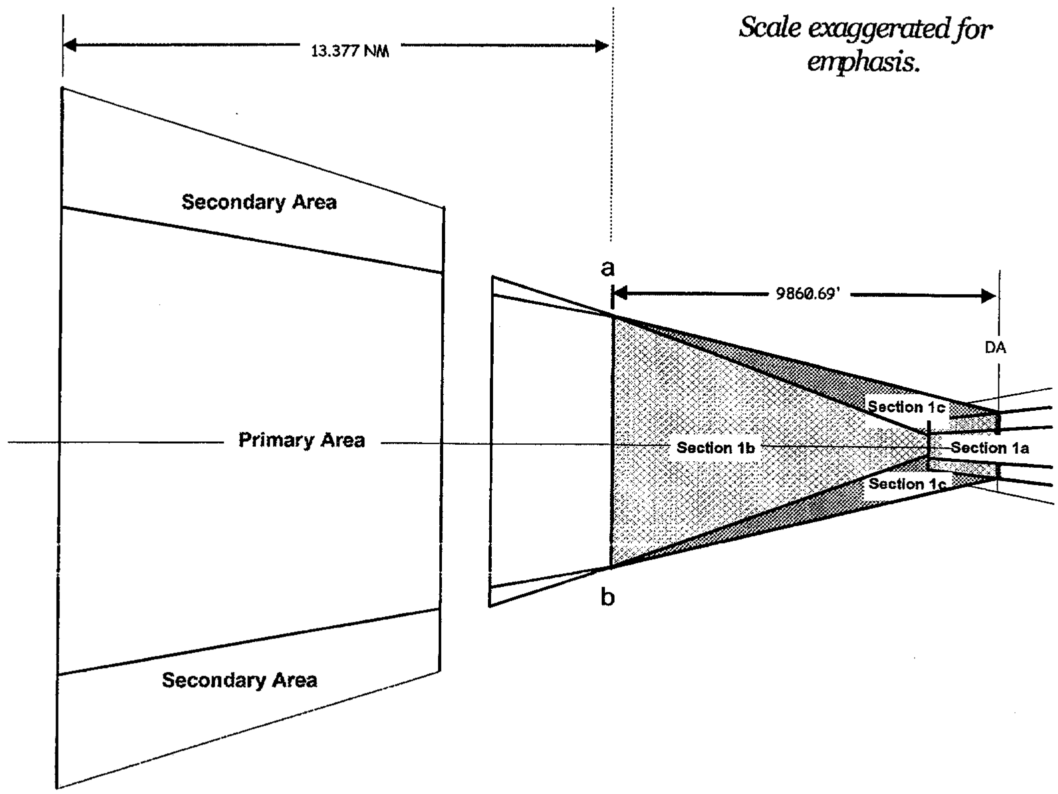
Figure 3-10B. Turning Missed Approach with Turn Fix at Greater than Minimum Distance



3.9.1 **e. Section 2. [Non-RNAV]**

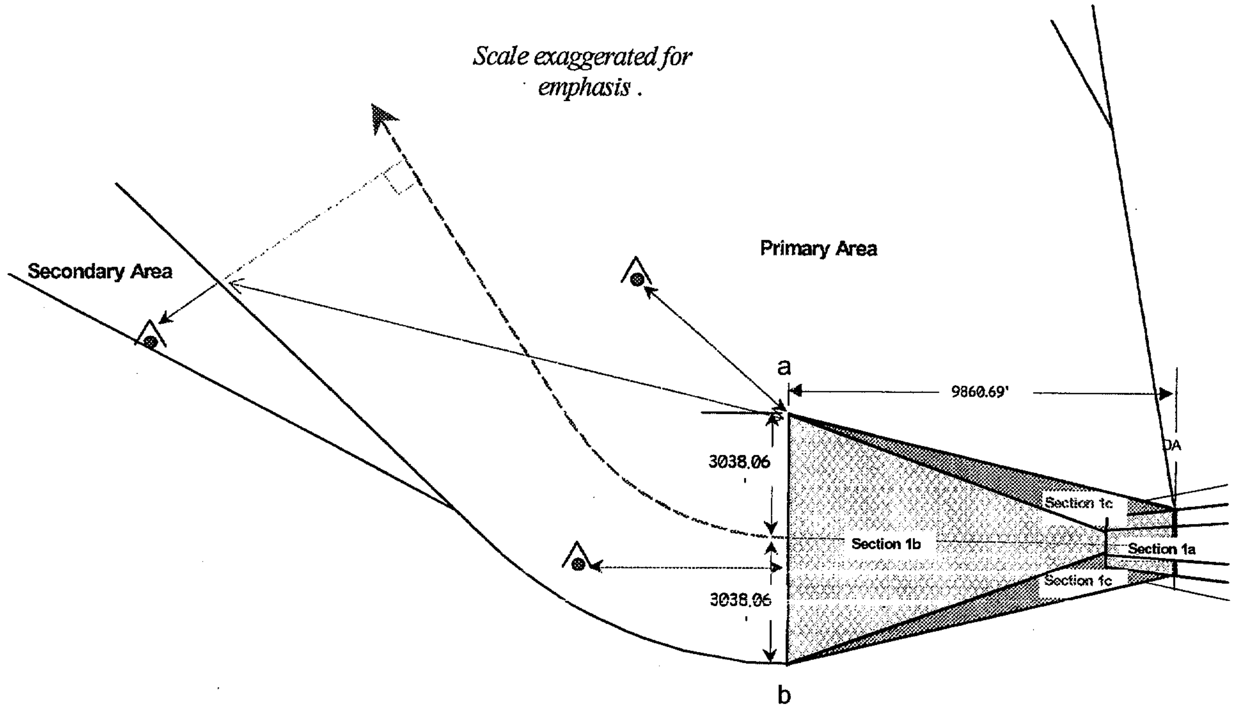
3.9.1 **e. (1) Straight-Ahead** (15° or less of final course heading). Section 2 is a 40:1 OCS that starts at the end of section 1 and is centered on the missed approach course. The width increases uniformly from 1 mile at the beginning to 12 miles at a point 13.377 miles from the beginning. A secondary area for reduction of obstacle clearance is identified within section 2. The secondary area begins at zero miles wide and increases uniformly to 2 miles wide at the end of section 2. PCG is required to reduce obstacle clearance in the secondary areas (see figure 3-11A). Use TERPS Volume 1, paragraph 277e, to determine if a climb-in-holding evaluation is required.

Figure 3-11A. Straight Missed Approach



3.9.1 **e. (2) Turning Missed Approach.** Where turns of MORE than 15° are required, design the procedure to begin the turn at an altitude at least 400 feet above the elevation of the TDZ. Assume the aircraft will be 175 feet above DA at the end of section 1b. Extend section 1b 30.39 feet for each additional foot of altitude necessary before a turn can commence. This point is where section 2 40:1 OCS begins. Specify the "climb to" altitude in the published missed approach procedure. The flight track and outer boundary radii used shall be as specified in TERPS Volume 1, table 5, paragraph 275. The inner boundary line shall commence at the edge of section 1 opposite the MAP. The outer and inner boundary lines shall expand to the width of the initial approach area 13.377 miles from the beginning of section 2. Secondary areas for reduction of obstacle clearance are identified within section 2. The secondary areas begin after completion of the turn (see figure 3-11B). They begin at zero miles wide and increase uniformly to 2 miles wide at the end of section 2. PCG is required to reduce obstacle clearance in the secondary area.

Figure 3-11B. Turning Missed Approach



3.9.1 **e. (3) Combination Straight-Turning Missed Approach Procedures.** Use TERPS Volume 1, paragraphs 277d and f to establish the charted missed approach altitude. Use TERPS Volume 1, paragraph 277e to determine if a climb-in-holding evaluation is required.

3.9.2 Missed Approach Climb Gradient (DOD Only).

Where the 40:1 OCS is penetrated and the lowest HAT is required, a mandatory missed approach climb gradient may be specified to provide ROC over the penetrating obstruction. Use the following formula to calculate the climb gradient (CG) in feet per NM.

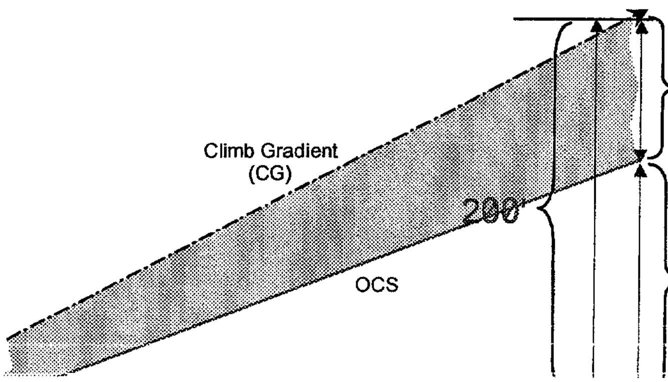
$$\frac{o-(DA-\tan(\theta)(1460)+276.52)}{0.76d}=CG \quad \text{Example: } \frac{1849-(613-\tan(3)(1460)+276.52)}{(0.76)(5.26)}=259.15\approx 260$$

Where o = MSL height of obstruction
d = shortest distance (NM) from end of section 1B to obstacle
θ = glidepath angle

3.9.3 Missed Approach ROC Rationale.

The obstacle clearance concept applied to the departure and missed approach climb maneuver in instrument procedures design is to enable the aircraft to gain sufficient altitude to supply at least the minimum ROC for the subsequent level surface segments of the procedure. The obstacle evaluation method for a climb maneuver is the application of a rising OCS below the minimum climbing flight path. The vertical distance between the climbing flight path and the OCS is ROC. The ROC and OCS slope values are dependent on a minimum aircraft climb performance of 200 ft/NM (see figure 3-12). Whether the climb is for departure or missed approach is immaterial. The standard for determining OCS slope is that 76% $\left(\frac{19}{25}\right)$ of the altitude gained defines the OCS slope; 24% $\left(\frac{6}{25}\right)$ of the altitude gained defines the ROC value.

Figure 3-12. ROC and OCS Slope Values



$$0.24 \times AG = ROC \text{ or } \frac{6}{25} \times AG = ROC$$

$$0.24 \times 200 = 48 \text{ ft/NM or } \frac{6 \times 200}{25} = 48 \text{ ft/NM}$$

$$0.76 \times AG = OCS \text{ or } \frac{19}{25} \times AG = OCS$$

$$0.76 \times 200 = 152 \text{ ft/NM or } \frac{19 \times 200}{25} = 152 \text{ ft/NM}$$

$$\frac{152}{6076.11548} \approx 1:40$$

The amount of ROC increases as the aircraft climbs until the point en route or initial segment ROC (1,000/2,000 feet as appropriate) is realized. After this point, application of a sloping surface for obstacle clearance purposes is not required. Where an obstacle penetrates the OCS, a greater than normal climb gradient (greater than 200 ft/NM) is required to provide adequate ROC. Since the climb gradient will be greater than 200 ft/NM, the ROC requirement will be greater than 48 ft/NM ($0.24 \times [Y > 200] = [Z > 48]$). The ROC expressed in ft/NM can be calculated using the formula: $\frac{0.24h}{0.76d}$ or $\frac{6h}{19d}$ where "h" is the height of the obstacle above the altitude from which the climb is initiated, and "d" is the distance in NM from the initiation of climb to the obstacle.

CHAPTER 4.
BAROMETRIC VERTICAL NAVIGATION (BARO VNAV)

4.0 GENERAL.

Design LNAV/VNAV approach procedures under these criteria. Baro VNAV operations are not authorized where remote altimeter is used, or in areas of precipitous terrain. The allowable range of glidepath angles is:

MINIMUM glidepath angle is 2.75°;
OPTIMUM glidepath angle is 3.00°,
MAXIMUM glidepath angle is 3.5°.

4.1 PUBLISHING ON RNAV CHARTS.

When published on an RNAV approach chart that depicts multiple lines of minima (LNAV/VNAV, LNAV, etc.), the TCH, GPA, course alignment, PFAF/FAF, and missed approach route and altitudes shall be identical for all depicted procedures. When minimums are based on remote altimeter and/or temperature settings, or the final segment overlies precipitous terrain, annotate the chart with a note to indicate Baro VNAV is not authorized. Where Baro VNAV is authorized, publish the minimum temperature for which the procedure was designed.

4.2 GROUND INFRASTRUCTURE.

If the airport obstacle free zones or the POFA are penetrated, LOWEST minimums are 300-foot ceiling and 3/4 mile visibility.

4.3 GLIDEPATH QUALIFICATION SURFACE (GQS).

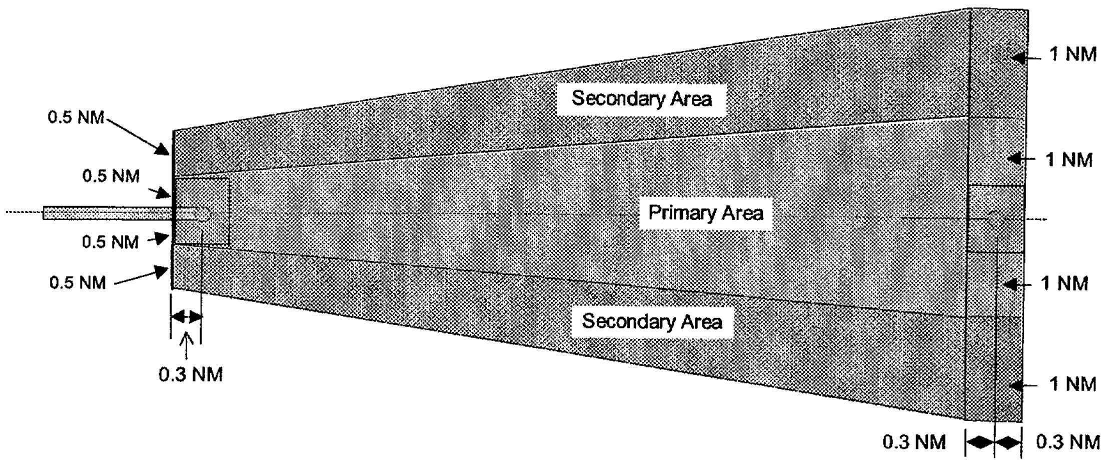
Penetrations of the GQS are not authorized. Apply paragraph 2.12.

4.4 FINAL APPROACH SEGMENT.

LNAV/VNAV procedures are based on the LNAV trapezoid. The Baro VNAV vertical surfaces conform to the LNAV trapezoid.

4.4.1 **Area.** See figure 4-1A.

Figure 4-1A. LNAV-VNAV Primary and Secondary Areas



4.4.2 Alignment.

The default final course aiming point is the LTP/FTP. OPTIMUM alignment is with the runway centerline (RCL) extended. The MAXIMUM offset from RCL is 15°. Approaches serving category A and B aircraft only may be designed with the offset course passing through the LTP/FTP regardless of degree of offset (see figure 4-1B). Where larger aircraft categories (CAT C, D, and E) are accommodated, the offset course must cross the RCL extended at least a MINIMUM distance from the RWT determined by the degree of offset, except as noted below:

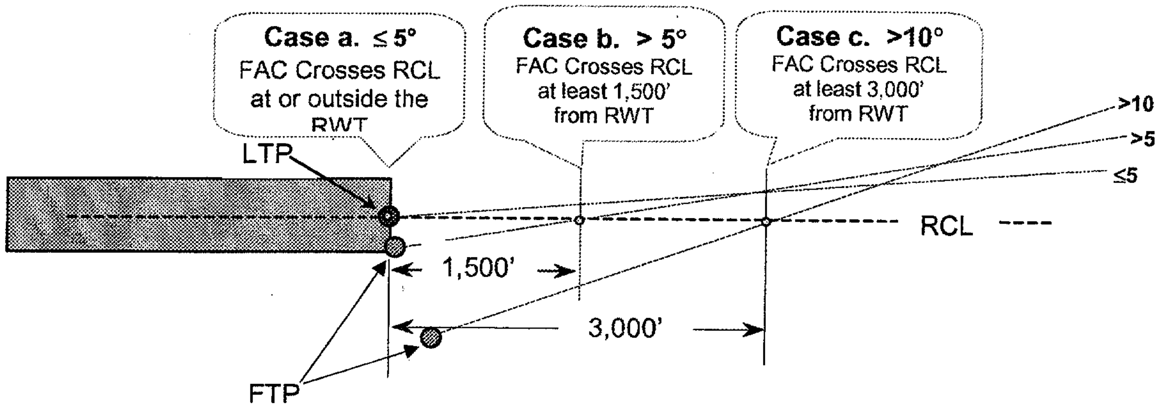
4.4.2 a. **Where the FAC is ≤5°** from the RCL alignment, the FAC shall cross the RCL at or outside the RWT.

4.4.2 b. **When the FAC is >5°** from RCL alignment, the FAC shall cross the RCL at least 1,500 feet from the RWT.

4.4.2 c. **When the FAC is >10°** from RCL alignment, the FAC shall cross the RCL at least 3,000 feet from the RWT.

NOTE: A FAC that intersects the RCL inside RWT, does not intersect the RCL extended or intersects at a distance greater than 3,000 feet from RWT may be established provided that the course lies laterally within 500 feet of the extended RCL at a point 3,000 feet outward from the RWT.

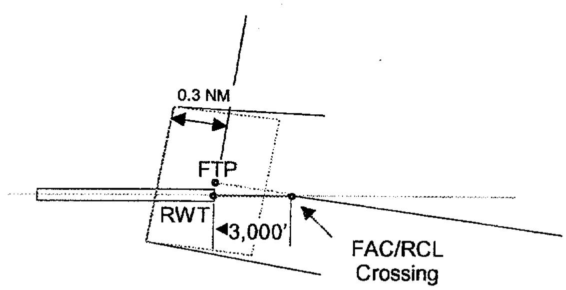
Figure 4-1B. Offset Final Course and RCL Extended Crossing Points



4.4.3 Length.

The primary OCS begins at the earliest point the FAF can be received and extends 0.3 NM past the RWT or FTP (see figures 4-1A, 4-1B, and 4-2).

Figure 4-2. End of Final Trapezoid, 15° Offset



4.4.4 Width.

4.4.4 a. Primary Area.

Calculate the perpendicular distance (D_Y) from the course extended to the outer boundary of the primary area for any distance (D) from RWT or FTP using the following formula:

$$DY = \frac{0.5\,NM}{L} \times (D + 1822.83) + 3038.06$$

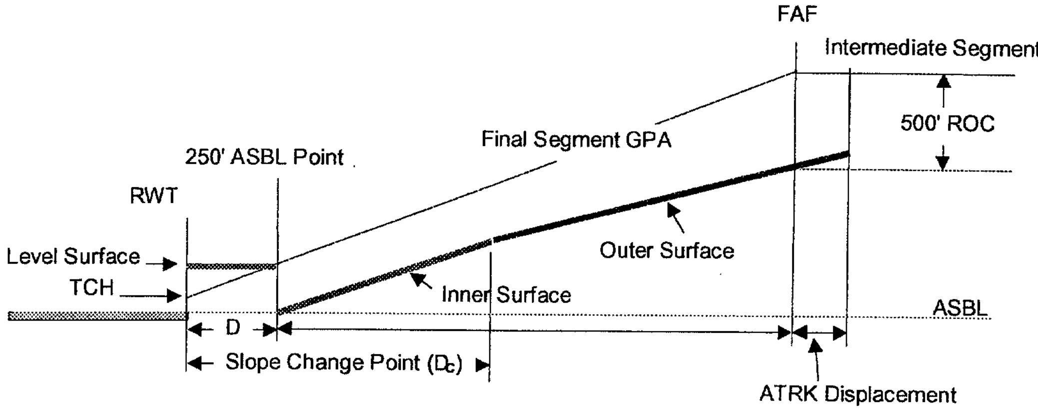
Where D = the distance in feet from RWT or FTP along course centerline
L = the final length in NM from plotted position of FAF to plotted position of RWT or FTP

4.4.4 b. Secondary Area.

The width of the secondary area is equal to the ½ width of the primary at any distance "D" from RWT or FTP (see paragraph 4.4.4a).

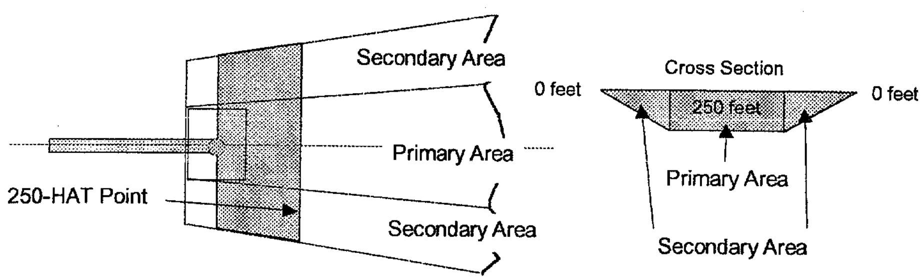
4.4.5 **Obstacle Clearance Between RWT and 250' ASBL Point** (see figure 4-3).

Figure 4-3. Baro VNAV OCS's



The area between the RWT or FTP and the 250 feet above ASBL point consists of primary and secondary ROC areas. Apply ROC in the appropriate shaded area below to arrive at a preliminary DA (pDA) (see figure 4-4).

Figure 4-4. Obstacle Clearance Inside the 250 Feet Above ASBL Point



In the primary area, apply 250 feet ROC to the highest obstruction (see figure 4-4). Calculate secondary area ROC using the following formulae:

$$D_P=\frac{3{,}038.06}{L}\times(D_X+1{,}822.83)+3038.06$$

Example: $\frac{3{,}038.06}{28{,}557.74}\times(3{,}000+1{,}822.83)+3{,}038.06=3{,}551.13$

$D_S=D_P$

$$ROC_S=\frac{250}{D_S}\times([2\times D_s]\text{-}D_y)$$

Example: $\frac{250}{3{,}551.15}\times([2\times 3{,}551.13]\text{-}4{,}200)=204.32$

Where

L = final length in feet (plotted position of FAF to plotted position of RWT or FTP).

DP=the distance in feet from course centerline to the primary area outer boundary.

D_S =the width of the secondary area at distance D_X.

D_X = the distance in feet from RWT or FTP to the obstacle measured along course centerline.

D_Y=the perpendicular distance in feet from course centerline to the obstacle.

Determine the pDA by adding the appropriate ROC value to the controlling obstruction height and round up to the next higher 20-foot increment.

4.4.6 Inner Surface.

The inner surface originates at the point on the ASBL corresponding distance from RWT that the glidepath reaches 250 feet above ASBL (see figure 4-3). Calculate the distance (D_{250}) from RWT or FTP to the OCS origin using the following formula:

$$D250=\frac{250-TCH}{\tan(\theta)} \qquad \text{Example: } \frac{250\text{-}53}{\tan(3)}=3758.98$$

Where θ = glidepath angle

Determine the slope of the inner surface (S_V) as follows:

STEP 1: Obtain the mean low temperature of the coldest month of the year for the last five years of data. If the data is given in Fahrenheit (°f), convert the temperature to Celsius (°c) and enter table 4-1. Use the following formulae to convert between Celsius and Fahrenheit temperatures:

$$°c = \frac{°f - 32}{1.8} \qquad \text{Example}: \frac{76 - 32}{1.8} = 24.44°c$$

$$°f = (1.8 \times °c) + 32 \qquad \text{Example}: (1.8 \times 24.44) + 32 = 75.99°f$$

STEP 2: Convert the mean temperature into a deviation from ISA using the following formula:

$$\text{deviation} = °c - \left[15°c - \left(\frac{\text{Airport Elevation}}{500}\right)\right] \qquad \text{Example}: -28 - \left[15°c - \left(\frac{1{,}528}{500}\right)\right] = -39.9°$$

Round deviation to the next lower 5°c increment. Use this rounded deviation or -15°c, whichever is lower, and the GPA to find the surface slope from table 4-1.

Table 4-1. S_V Considering GPA and International Standard Atmosphere (ISA) Temperature Deviation

ISA (C) DEV	2.7	2.8	2.9	3.0	3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.8
-10	23.2	22.4	21.7	21.0	20.4	19.8	19.3	18.8	18.3	17.8	17.4	17.0
-15	23.8	23.0	22.2	21.6	20.9	20.3	19.8	19.3	18.8	18.3	17.9	17.5
-20	24.4	23.6	22.9	22.2	21.5	20.9	20.3	19.8	19.3	18.8	18.4	18.0
-25	25.1	24.3	23.5	22.8	22.1	21.5	20.9	20.4	19.9	19.4	18.9	18.5
-30	25.8	25.0	24.2	23.4	22.8	22.1	21.5	21.0	20.5	20.0	19.5	19.1
-35	26.6	25.7	24.9	24.1	23.4	22.8	22.2	21.6	21.1	20.6	20.1	19.6
-40	27.4	26.5	25.7	24.9	24.2	23.5	22.9	22.3	21.7	21.2	20.7	20.3
-45	28.2	27.3	26.5	25.7	24.9	24.2	23.6	23.0	22.4	21.9	21.4	20.9
-50	29.1	28.2	27.3	26.5	25.8	25.0	24.4	23.8	23.2	22.6	22.1	21.6

NOTE: IF the glidepath angle falls between table values, use the higher value.

4.4.7 Outer Surface.

Calculate the slope of the outer surface (S_W) appropriate for the glidepath angle (θ) using the following formula: $S_W = \frac{102}{\theta}$ The outer surface begins at point "c" and ends at the earliest point the FAF can be received (see figure 4-3). Calculate the distance (D_C) from RWT or FTP to point C using the following formula

$$D_C = \frac{(a \times S_W) - (200 \times S_V)}{(S_W - S_V)}$$

Where a=distance from RWT or FTP to OCS origin (D_{250})

4.4.8 Height of the OCS.

4.4.8 **a. Calculate the height** (I_Z) above ASBL of the inner surface using the following formula:

$$I_Z = \frac{D_O - D_{250}}{S_V}$$

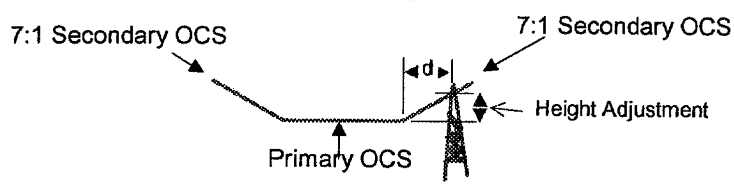
Where D_O = the distance in feet from the RWT or FTP to the obstacle
D_{250} = the distance from the RWT or FTP origin to the inner surface origin

4.4.8 b. **Calculate the height** (O_Z) above ASBL of the outer OCS using the following formula:

$$O_Z = \frac{(D_O - 200) \times GPA}{102}$$

4.4.8 c. **The secondary OCS** has a slope of 7:1 measured perpendicular to the segment centerline. To evaluate the height of a secondary OCS obstruction, reduce the obstruction height by the amount of secondary surface rise from the edge of the primary OCS (see figure 4-5). Then evaluate the revised height of the obstruction against the height of the primary OCS abeam the obstruction.

Figure 4-5. Secondary OCS Evaluation



Cross Section

Height Adjustment $= \frac{d}{7}$

Where d = distance in feet from edge of primary OCS measured perpendicular to the segment centerline.

4.4.9 **OCS Penetrations.**

Obstructions should not penetrate the OCS. If the OCS is clear, publish the pDA value. If the OCS is penetrated, take one of the following actions. These actions are listed in order of preference.

ACTION 1: Remove or adjust the obstruction location and/or height.

ACTION 2: Raise glidepath angle.

ACTION 3: Adjust DA.

4.4.9 a. **Adjustment of DA for Penetration of INNER SURFACE**.

CASE 1: If elevation (revised elevation if paragraph 4.4.8c applied) of the obstacle is less than the elevation of point C ($C_{elevation}$):

$$C_{elevation}=E+\frac{D_C-D_{250}}{S_V}$$

$$DA_{adjusted}=E+\tan(\theta)\left(\left(D_O+\frac{TCH}{\tan(\theta)}\right)+(p\times S_V)\right)$$

Where θ = glidepath angle
D_O = distance (ft) to obstacle from LTP measured parallel to FAC
p = amount of penetration (ft)
S_V = slope of inner surface
E = LTP elevation (ft)

CASE 2: If the elevation (revised elevation if paragraph 4.4.8c applied) of the obstacle is equal to or greater than the elevation of point C:

$$DA_{adjusted}=E+\tan(\theta)\left[([h-c]S_W)+D_C+\frac{TCH}{\tan(\theta)}\right]$$

Where h = obstacle MSL elevation (revised elevation if para 4.4.8c applied)
c = elevation (MSL) of point C

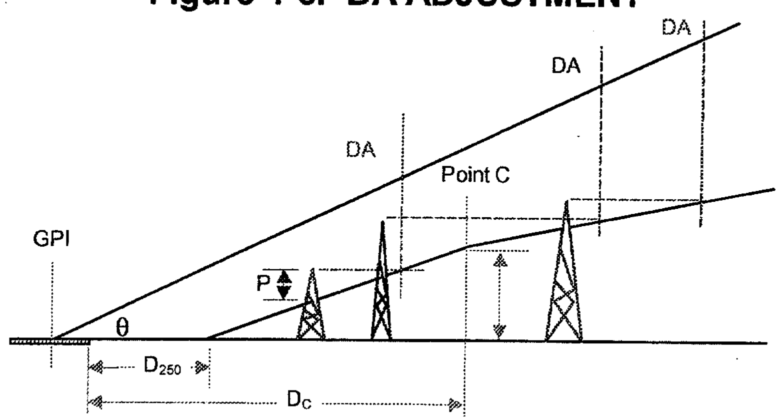
4.4.9 **b. Adjustment of DA for penetration of OUTER SURFACE** (see figure 4-6):

$$DA_{adjusted}=E+\tan(\theta)\left[(pS_W)+D_O+\frac{TCH}{\tan(\theta)}\right]$$

$$\text{Distance LTP to } DA_{adjusted}=\frac{DA_{adjusted}-E}{\tan(\theta)}-\frac{TCH}{\tan(\theta)}$$

Where $DA_{adjusted}$=Adjusted DA (MSL)

Figure 4-6. DA ADJUSTMENT



4.5 VISIBILITY MINIMUMS.

To determine visibility minimums, refer to TERPS Volume 1, chapter 3 for localizer procedures.

4.6 MISSED APPROACH SEGMENT.

Height loss is assumed after DA. The missed approach area begins at the cd line prior to the DA point. Apply RNAV departure criteria (Order 8260.44) from the segment origin to the missed approach holding fix. Locate the first fix encountered after DA at least 9,114 feet from the ab line and a maximum of 5 NM. If a turn is associated with a fly-by fix, the minimum distance is 9,114+DTA (see figures 4-7 and 4-8A and 4-8B).

Figure 4-7. Straight Missed Approach Surfaces

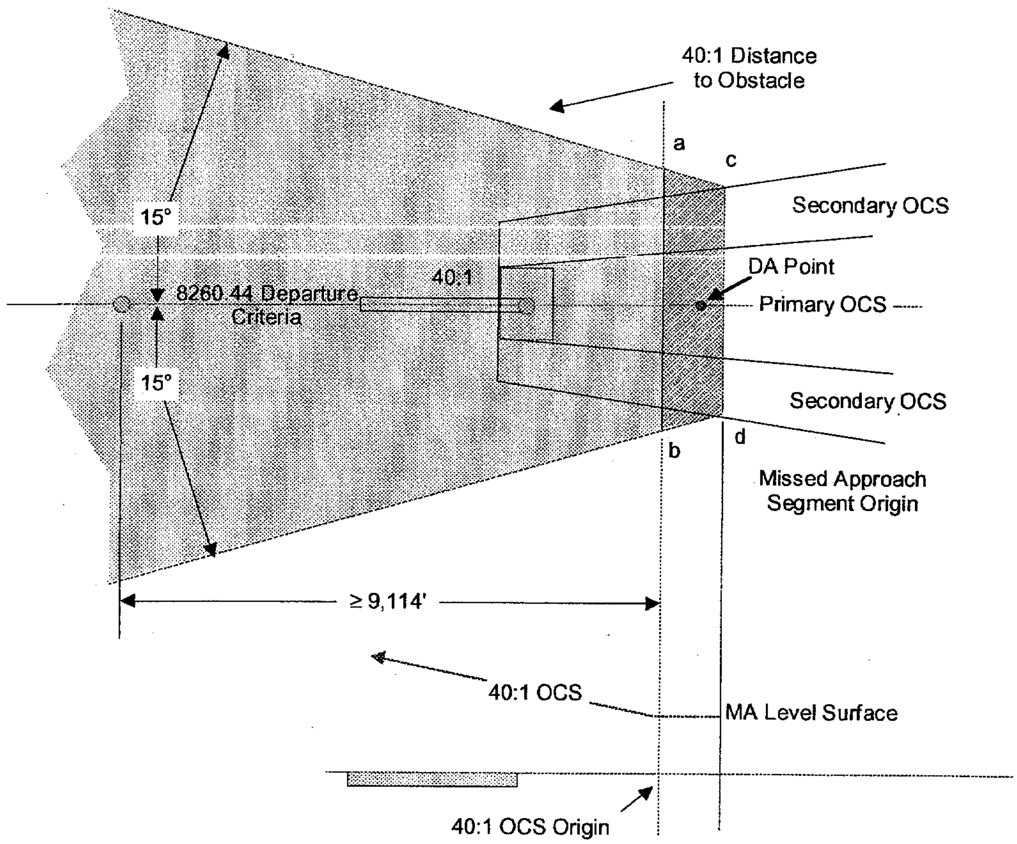


Figure 4-8A. Turning Approach Surfaces Minimum Distance from DA to Turn Fix

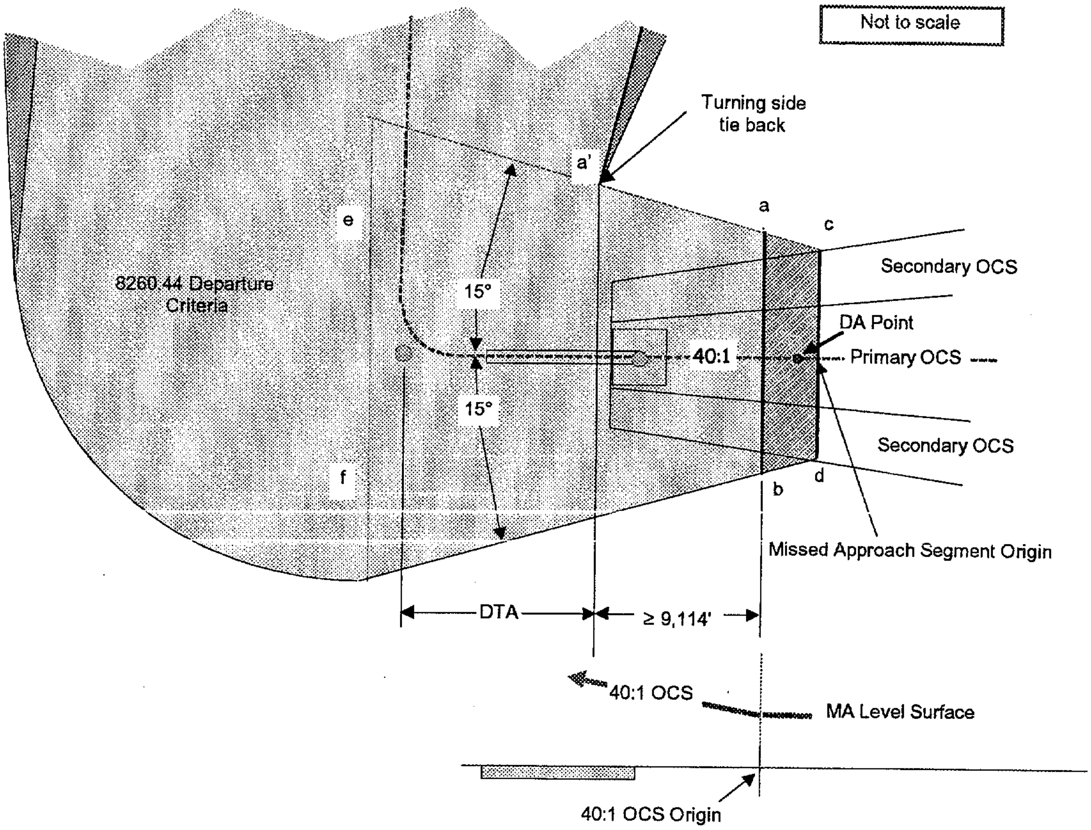
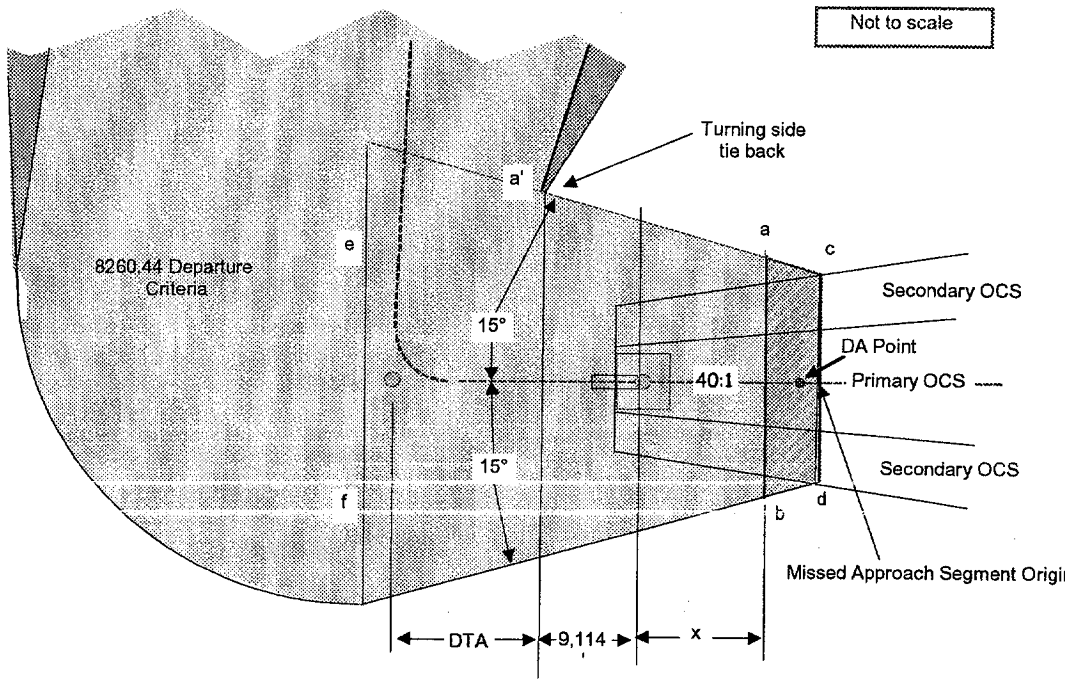


Figure 4-8B. Turning Approach Surfaces Greater than Minimum Distance from DA to Turn Fix



4.6.1 Area.

4.6.1 a. Level Surface. See figure 4-9.

The level surface accounts for possible along track errors inherent with barometric altimetry and allows an aircraft to lose (dip down) 50 feet prior to commencing climb.

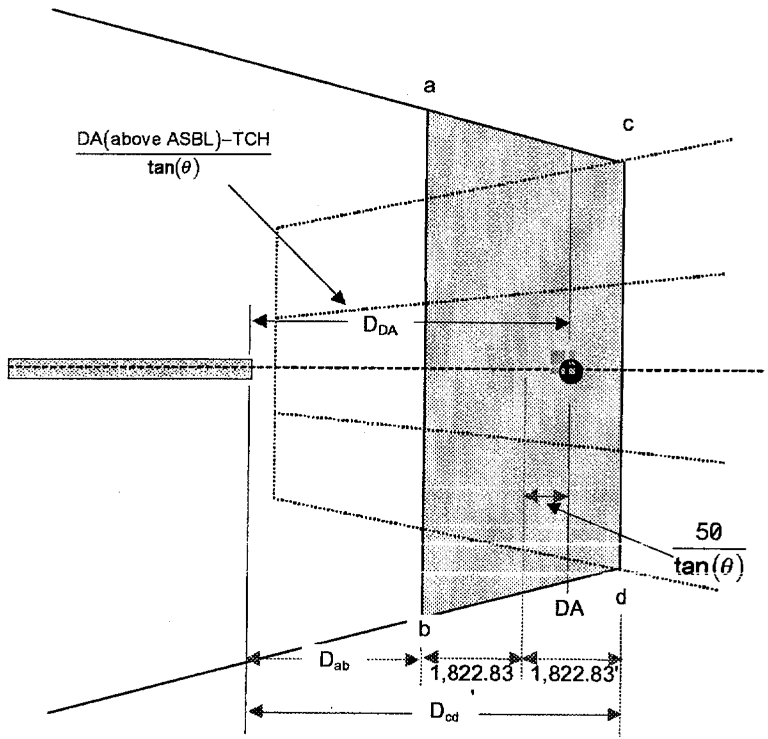
4.6.1 **a. (1) Length.** Calculate the distance (D_{cd}) from RWT to the **origin** of the MA segment (<u>cd</u> line), and the distance (D_{ab}) from RWT to the end of the level surface (<u>ab</u> line), using the following formulae:

$$D_{cd} = \frac{DA - (E + TCH)}{\tan(\theta)} - \frac{50}{\tan(\theta)} + 1822.83$$

$$D_{ab} = D_{cd} - 3645.66$$

Where E = RWT elevation
θ = GPA

Figure 4-9. Level Surface



4.6.1 **a. (2) Width.** The area splays at 15° relative to the MA course beginning at the secondary outer boundary at the cd line (see figure 4-9).

4.6.1 **a. (3) OCS.** A level surface overlies the primary area. Where obstructions penetrate the OCS, increase the DA by the value of the penetration. The height of the MA LEVEL OCS (MSL) is determined by the formula:

$$\text{hmas} = \text{DA} - \text{ROC}$$

4.6.1 **b. 40:1 Surface.** Apply Order 8260.44 criteria.

4.6.1 **b. (1) Length.** The 40:1 surface begins at the ab and extends along the MA course until the clearance limit.

4.6.1 **b. (2) Width.** The primary area splays as specified in Order 8260.44 relative to the MA course beginning at the final primary outer boundary at the cd line (see figure 4-9).

4.6.1 **b. (3) OCS.** Where obstructions penetrate the OCS, increase the DA by the value ($DA_{adjustment}$) calculated by the following formula:

$$DA_{adjustment} = \frac{\theta(40p)}{102}$$

Where p = amount of penetration in feet

4.6.1 c. Missed Approach Altitude.

4.6.1 c. (1) **Straight Missed Approach Procedures.** Use TERPS paragraphs 274b and d to establish the charted missed approach altitude. Use TERPS paragraph 274c to determine if a climb-in-holding evaluation is required.

4.6.1 c. (2) **Combination Straight Turning Missed Approach Procedures.** Use TERPS paragraphs 277d and f to establish the charted missed approach altitude. Use TERPS paragraph 277e to determine if a climb-in-holding evaluation is required.

APPENDIX 1. CATEGORY (CAT) II AND III PRECISION MINIMUMS REQUIREMENTS

RESERVED

APPENDIX 2. SIMULTANEOUS ILS PROCEDURES

1.0 GENERAL.

Simultaneous dual and triple ILS approach procedures using ILS installations with parallel courses may be authorized when the minimum standards in this appendix and chapter 2 of this Volume are met.

2.0 SYSTEM COMPONENTS.

Simultaneous ILS approach procedures require the following basic components:

2.1 AN ILS IS SPECIFIED IN CHAPTER 2 OF THIS VOLUME FOR EACH RUNWAY.

Adjacent markers of the separate systems shall be separated sufficiently to preclude interference at altitudes intended for use.

2.2 ATC APPROVED RADAR FOR MONITORING SIMULTANEOUS OPERATIONS.

3.0 INOPERATIVE COMPONENTS.

When any component specified in paragraph 2.0 becomes inoperative, simultaneous ILS approaches are not authorized on that runway.

4.0 FEEDER ROUTES AND INITIAL APPROACH SEGMENT.

The criteria for feeder routes and the initial approach segment are contained in Volume 1, chapter 2, paragraph 2.3. The initial approach shall be made from a facility or satisfactory radio fix by radar vector. Procedure and penetration turns shall not be authorized.

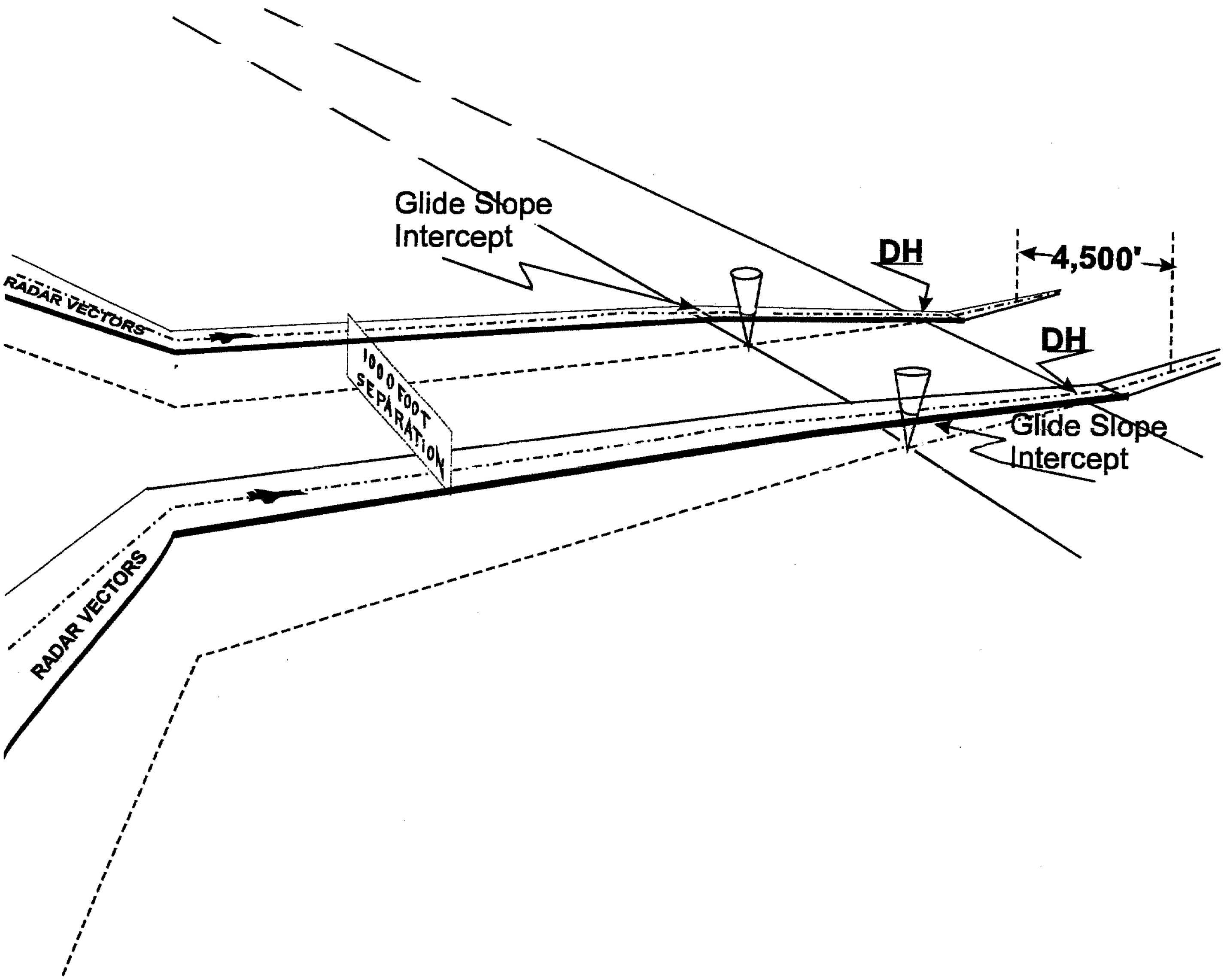
4.1 ALTITUDE SELECTION.

In addition to obstacle clearance requirements, the altitudes established for initial approach shall provide the following vertical separation between glide slope intercept altitudes:

4.1.1 Dual.

Simultaneous dual ILS approaches shall require at least 1,000 feet vertical separation between glide slope intercept altitudes for the two systems (see figure A2-1).

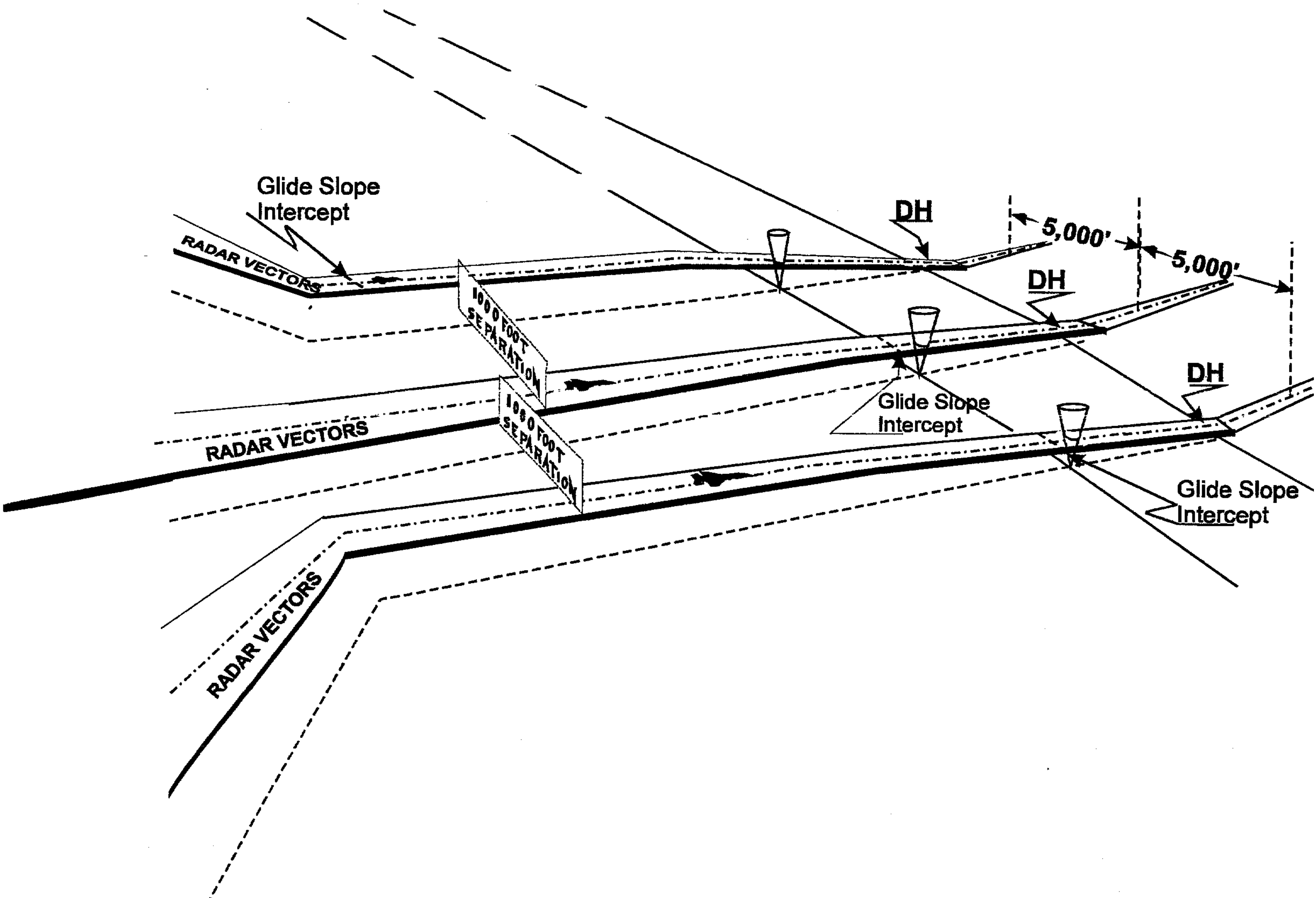
Figure A2-1. Initial Approach Segment, Simultaneous ILS



4.1.2 **Triple.**

Simultaneous triple ILS approaches shall require at least 1,000 feet vertical separation between GS intercept altitudes for any combination of runways. No two runways share the same GS intercept altitude (see figure A2-2).

Figure A2-2. Initial Approach Segment for Triple Simultaneous ILS



4.2 LOCALIZER INTERCEPT POINT.

The localizer intercept point shall be established UNDER chapter 2, paragraph 2.3 of this Volume. Intercept angles may not exceed 30°; 20° is optimum.

5.0 INTERMEDIATE APPROACH SEGMENT.

Criteria for the intermediate segment are contained in Volume 1, paragraphs 241 and 242, except that simultaneous ILS procedures shall be constructed with a straight intermediate segment aligned with the final approach course (FAC), and the minimum length shall be established in accordance with chapter 2, paragraph 2.3.1 of this Volume. The intermediate segment begins at the point where the initial approach intercepts the FAC. It extends along the inbound course to the GLIDE SLOPE intercept point.

6.0 FINAL APPROACH SEGMENT.

Criteria for the final approach segment are contained in chapter 3 of this Volume.

7.0 FINAL APPROACH COURSE (FAC) STANDARDS.

The FAC's for simultaneous ILS approaches require the following:

7.1 DUAL APPROACHES.

The MINIMUM distance between parallel FAC's is 4,300 feet.

7.2 TRIPLE APPROACHES.

The MINIMUM distance between parallel FAC's is 5,000 feet. For triple parallel approach operations at airport elevations above 1,000 feet MSL, ASR with high-resolution final monitor aids or high update radar with associated final monitor aids is required.

7.3 NO TRANSGRESSION ZONE (NTZ).

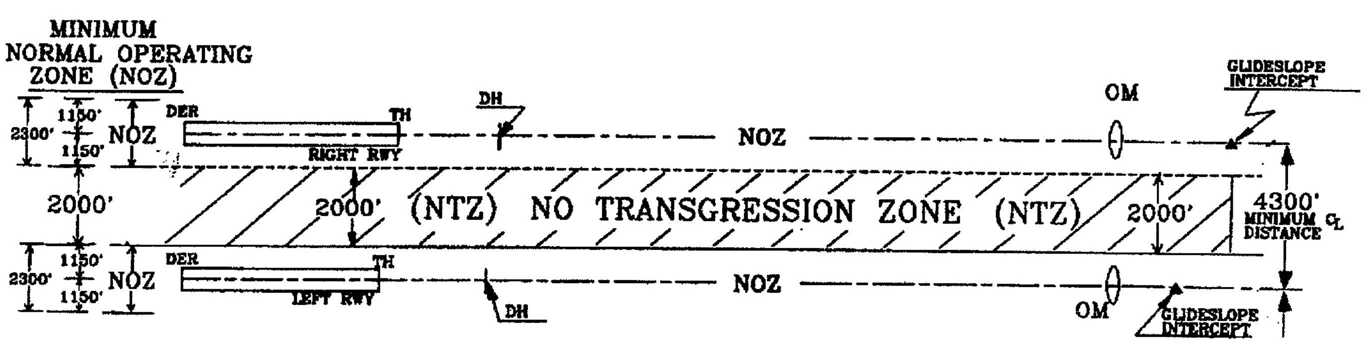
The NTZ shall be 2,000 feet wide equidistant between FAC's.

7.4 NORMAL OPERATING ZONE (NOZ).

The area between the FAC and the NTZ is half of the NOZ.

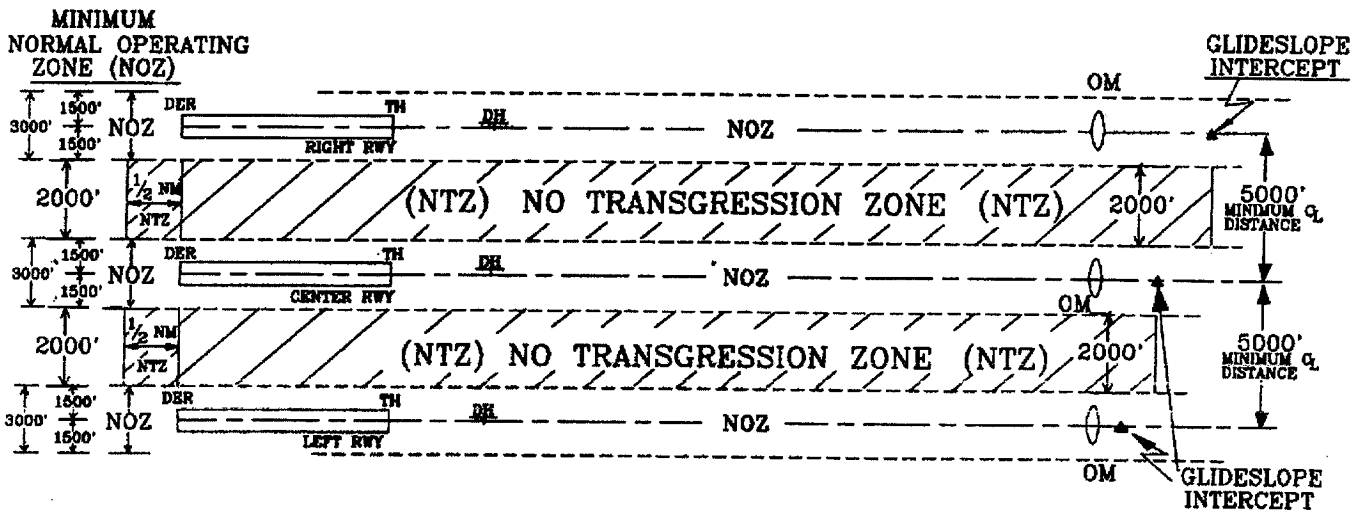
7.4.1 **The NOZ for dual simultaneous ILS approaches** shall not be less than 1,150 feet in width each side of the FAC (see figure A2-3).

Figure A2-3. Dual Simultaneous ILS "No Transgression And Normal Operating Zones"



7.4.2 **The NOZ for triple simultaneous ILS approaches** shall not be less than 1,500 feet in width each side of the FAC (see figure A2-4).

Figure A2-4. Triple Simultaneous ILS "No Transgression Zone and Normal Operating Zones"



8.0 MISSED APPROACH SEGMENT.

Except as stated in this paragraph, the criteria for missed approach are contained in chapter 3 of this Volume. A missed approach shall be established for each of the simultaneous systems. The minimum altitude specified for commencing a turn on a climb straight ahead for a missed approach shall not be less than 400 feet above the TDZE.

8.1 DUAL.

Missed approach courses shall diverge a minimum of 45°.

8.2 TRIPLE.

The missed approach for the center runway should continue straight ahead. A minimum of 45° divergence shall be provided between adjacent missed approach headings. At least one outside parallel shall have a turn height specified that is not greater than 500 feet above the TDZE for that runway.

APPENDIX 3. CLOSE PARALLEL ILS/MLS APPROACHES

1.0 BACKGROUND.

Extensive tests have disclosed that under certain conditions, capacity at the nation's busiest airports may be significantly increased with independent simultaneous parallel approaches to runways that are more closely spaced than the minimum of 4,300 feet. Tests have shown that a reduction in minimum separation between parallel runways may be achieved by use of high update radar with high-resolution displays and automated blunder alerts.

2.0 TERMINOLOGY.

2.1 AUTOMATED ALERT.

A feature of the PRM that provides visual and/or audible alerts to the monitor controller when an aircraft is projected to enter or has entered the NTZ. Paragraph 3.1.2 defines the precision runway monitor (PRM) systems alerts.

2.2 BREAKOUT.

A technique to direct aircraft out of the approach stream. In the context of close parallel operations, a breakout is used to direct threatened aircraft away from a deviating aircraft.

2.3 CLOSE PARALLELS.

Two parallel runways whose extended centerlines are separated by at least 3,400 feet, but less than 4,300 feet, having a precision runway monitoring system that permits simultaneous independent ILS/MLS approaches. Runways are separated by less than 3,400 to 3,000 feet with a localizer offset of not more than 3.0°.

2.4 E-SCAN RADAR.

An electronically scanned phased array radar antenna that is cylindrical and stationary. It consists of interrogators and a surveillance processor providing an azimuth accuracy of at least 1 milliradian (0.057°) remote monitoring subsystem (RMS) and an update interval of not more than 1.0 second.

2.5 LOCALIZER/AZIMUTH OFFSET.

An angular offset of the localizer/azimuth from the runway extended centerline in a direction away from the no transgression zone (NTZ) that increases the normal operating zone (NOZ) width.

2.6 MONITOR ZONE.

The monitor zone is the volume of airspace within which the final monitor controllers are monitoring close parallel approaches and PRM system automated alerts are active.

2.7 NO TRANSGRESSION ZONE (NTZ).

The NTZ is a 2,000-foot wide zone, located equidistant between parallel runway final approach courses in which flight is not allowed (see figure A3-1).

2.8 NORMAL OPERATING ZONE (NOZ).

The NOZ is the operating zone within which aircraft flight remains during normal independent simultaneous parallel approaches (see figure A3-1.)

2.9 PRECISION RUNWAY MONITOR (PRM).

A specialized ATC radar system providing continuous surveillance throughout the monitoring control zone. It includes a high accuracy, high update rate sensor system, and for each runway, a high resolution color FMA with automated alerts. The PRM system provides each monitor controller with a clear, precise presentation of aircraft conducting approaches.

3.0 GENERAL.

Criteria contained in this appendix are designed for independent simultaneous precision ILS or MLS operations to dual parallel runways with centerlines separated by at least 3,000 feet, but less than 4,300 feet. Simultaneous close parallel operations at airport elevations above 1,000 feet MSL and deviations from these criteria or glidepath angles above the U.S. civil standard of 3.0° shall not be established without approval from the Flight Standards Service, FAA, Washington, DC. When runway spacing is less than 3,400 feet, but not less than 3,000 feet, the localizers/azimuth stations in the close runway pair must be aligned at least 2-1/2° divergent from each other, but not more than 3.0°, and an electronically scanned (E-Scan) radar with an update interval of 1.0 second must be employed. All close parallel ILS/MLS operations require final approach radar monitoring, accurate to within 1.0 milliradian, an update interval of 1.0 second, and a final monitor aid (a high resolution display with automated blunder alerts). In these criteria, ILS "glide slope/localizer" terms are synonymous to and may be used inter-changeably with MLS "elevation/azimuth" terms. Independent simultaneous close parallel approaches without altitude separation should not be authorized at distances greater than 10 NM from threshold. If Air Traffic Control (ATC) systems and procedures are established which assure minimal NTZ intrusions, this distance may be extended up to 12.5 NM. A separate instrument approach chart described as a special close parallel ILS/MLS procedure shall be published for each runway in the close parallel pair of runways. This special close parallel ILS/MLS procedure is to be identified in accordance with paragraph 3.1. A standard ILS/MLS procedure may also exist or be published for each of the runways. During close parallel ILS/MLS operations, the close parallel ILS/MLS may overlay the existing standard ILS/MLS procedure, provided that spacing localizer/azimuth alignment is less than 3,400 feet and the missed approaches diverge. A breakout obstacle assessment specified in Volume 3, appendix 4, Obstacle Assessment Surface Evaluation for Simultaneous Parallel Precision Operations, shall be completed as part of the initial evaluation for parallel operations.

3.1 SYSTEM COMPONENTS.

Simultaneous close parallel approach procedures are not authorized if any component of the PRM system is inoperative. System requirements for simultaneous close parallel approach procedures are:

3.1.1 **ILS/MLS.** A full ILS or MLS on each runway.

3.1.2 **PRM.** A PRM system includes the following:

3.1.2 **a. Radar**. Phased array electronically scanned (E-Scan) antenna; update intervals of 1.0 second.

3.1.2 **b. Final Monitor Aid (FMA).** Large (not less than 20" x 20"), high resolution (100 pixels/inch minimum), color monitors with associated visual and audible alerts.

3.1.2 **b. (1) Caution Alert.** A caution alert when the system predicts that an aircraft will enter the NTZ within 10 seconds (e.g., the target symbol and data block change from green to yellow and a voice alert sounds).

3.1.2 **b. (2) Warning Alert.** A warning alert when the aircraft has penetrated the NTZ (e.g., the target symbol and data block change to red).

3.1.2 **b. (3) A Surveillance Alert.** A surveillance alert when the track for a monitored aircraft inside the monitor zone has been in a coast state for more than three consecutive updates (e.g., the target symbol and data block change to red).

3.2 PROCEDURE CHARTING.

Volume 1, paragraph 161, applies, except where a separate procedure is published. In this case, **"ILS/MLS PRM"** should precede the approach title identification; e.g., **"ILS PRM, RWY 27R"** (simultaneous close parallel). Notes for approach charts for use in the close parallel operation shall be published in bold and caps as follows: **"SIMULTANEOUS CLOSE PARALLEL APPROACHES AUTHORIZED WITH RUNWAYS (NUMBER) L/R"** and **"LOCALIZER ONLY NOT AUTHORIZED DURING CLOSE-PARALLEL OPERATIONS."** The following shall also be noted: **"DUAL VHF COMM**

REQUIRED," "MONITOR PRM CONTROLLER (FREQ) ON RWY ( ) L, (FREQ) ON RWY ( ) R," and "SEE ADDITIONAL REQUIREMENTS ON ADJACENT INFORMATION PAGE."

4.0 FEEDER ROUTES AND INITIAL APPROACH SEGMENT.

Volume 3, chapter 2, paragraph 2.3 applies, except as stated in this order. The initial approach shall be made from a NAVAID, fix, or radar vector. Procedure turns and high altitude penetration procedures shall not be authorized.

4.1 ALTITUDE SELECTION.

Altitudes selected shall provide obstacle clearance requirements and a minimum of 1,000 feet vertical separation between aircraft on the two parallel final approach courses in the interval from localizer intercept to glide slope capture.

4.2 LOCALIZER INTERCEPT POINT.

Apply chapter 2 of this Volume, except optimum localizer intercept angles are 20° or less and the maximum intercept angle shall not exceed 30°.

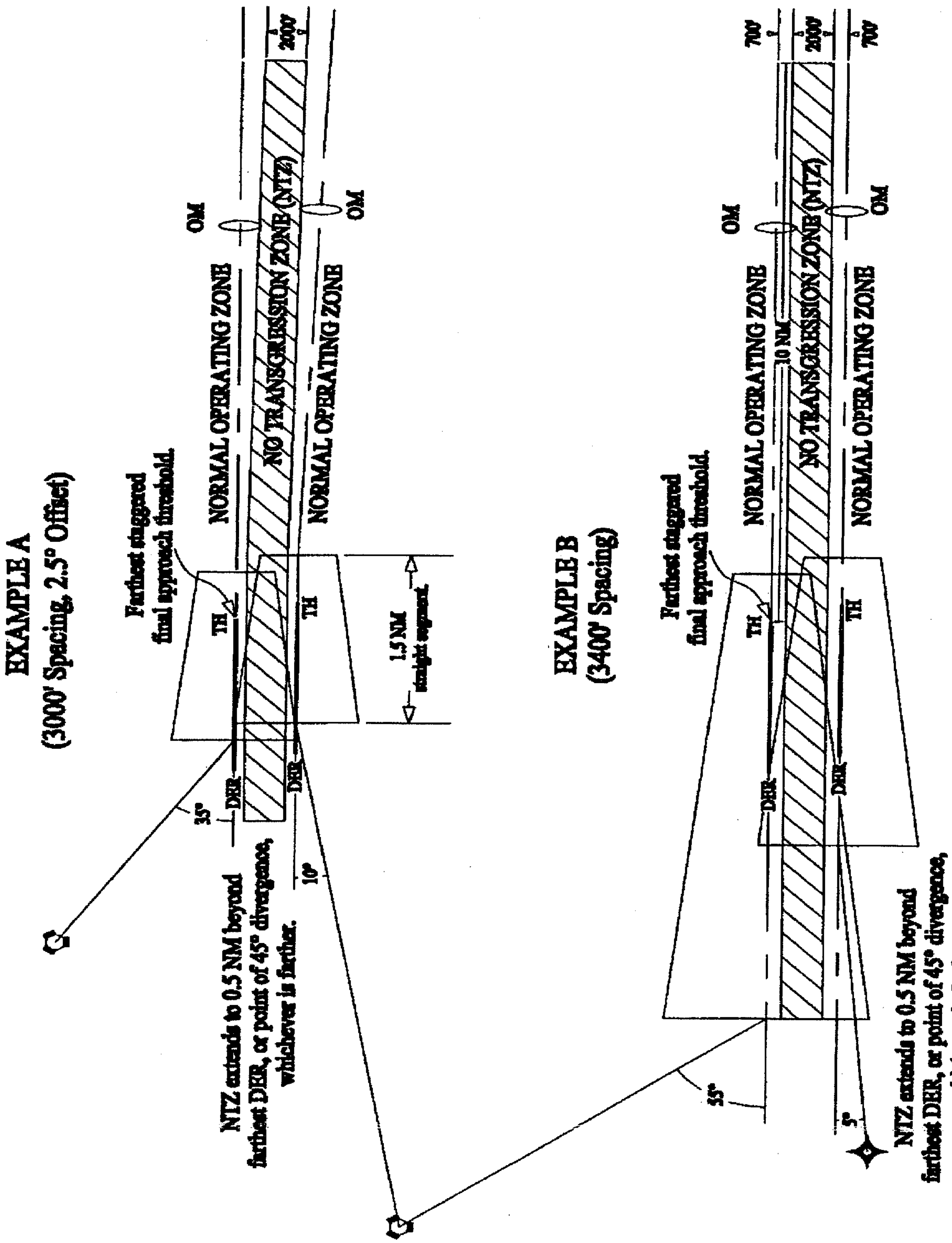
4.3 NTZ.

An NTZ is established and depicted on the FMA as a protected zone 2,000 feet wide, equidistant between parallel runway centerlines, beginning from the point where adjacent inbound aircraft first lose 1,000 feet of vertical separation, and extends to 0.5 NM beyond the farthest departure end of runway (DER), or the point where a combined 45° divergence occurs, whichever is farthest. The beginning of the NTZ for the final segment should begin at the most distant PFAF (see figure A3-1). Where an offset localizer is determined to provide operational advantage, the NTZ shall be established for the final segment equidistant between adjacent final approach courses beginning and ending as stated above.

4.4 NOZ.

An NOZ is established so that the NOZ for each close parallel runway is not less than 700 feet wide on each side of the approach course at any point. The width of the NOZ is equal on each side of the final approach course centerline, and the half-width is defined by the distance from the nearest edge of the NTZ to the final approach course centerline. The length of the NOZ equals the length of the NTZ. Each parallel runway provides an NOZ for the final and missed approach segments that equal the length of the NTZ (see figure A3-1)

Figure A3-1. Examples of Close Parallel Finals and Missed Approach Segments, Runway Spacing 3,000′ and 3,400′



5.0 INTERMEDIATE APPROACH SEGMENT.

Chapter 2, paragraph 2.3, of this Volume applies, except where close parallel procedures have a straight intermediate segment aligned with the final approach course. Where an existing ILS/MLS procedure is published with a transition intercept angle greater than 30° which cannot be reduced, a separate close parallel procedure shall be established with intercept angles of less than 30°.

6.0 FINAL APPROACH SEGMENT.

Volume 3 chapter 3 applies. In addition to these criteria, independent simultaneous approaches to close parallels runways require the following:

6.1 CLOSE PARALLEL APPROACH RUNWAY SEPARATION.

Approaches shall have a minimum of 3,400 foot separation between the parallel final approach courses.

6.2 PRM.

A PRM system must be in operation and providing service in accordance with paragraph 3.1.2.

6.3 NTZ.

An appropriate NTZ shall be established between close parallel final approach courses as described in paragraph 4.3 (see figure A3-1).

6.4 NOZ.

Appropriate NOZ's shall be established for each parallel final approach segment as described in paragraph 4.4 (see figure A3-1).

6.5 STAGGERED RUNWAY THRESHOLDS.

Where thresholds are staggered, the glide slope intercept point from the most distant runway approach threshold should not be more than 10 NM. It is recommended that the approach with the higher intercept altitude be the runway having the most distant approach threshold (from the point of view of an aircraft on approach).

6.6 LOCALIZER/AZIMUTH OFFSET.

Where an offset localizer is utilized, apply chapter 3 of this Volume. Where approach thresholds are staggered, the offset localizer course should be to the runway having the nearest approach threshold (from the point of view of an aircraft on approach). An offset requires a 50-foot increase in decision height

(DH) and is not authorized for Category II and III approaches. (Autopilots with autoland are programmed for localizers to be on runway centerline only.) The NTZ shall be established equidistant between final approach courses.

6.7 MONITOR ZONE.

This zone is a radar-monitored volume of airspace within which the PRM system automated alerts are active. The extent of the monitor zone is:

6.7.1 **Monitor Zone Length.** The PRM monitor zone begins where aircraft conducting simultaneous parallel approaches reach less than 1,000-foot vertical separation during final approach (typically at glide slope intercept for the higher altitude localizer intercept) and extends to 0.5 NM beyond the farthest DER, or the point where a 45° divergence occurs, whichever generates the greatest length for the monitor zone.

6.7.2 **Monitor Zone Width.** The PRM monitor zone (automated alerts) includes all of the area between the final approach courses and extends 0.5 NM outboard of each final approach course centerline.

6.7.3 **Monitor Zone Height.** The PRM monitor zone height may be defined in as many as five separate segments, each having an independent maximum height. Each segment covers the entire monitor zone width, and a portion of the monitor zone length. Within each segment, the monitor zone height extends from 50 feet above ground level to a minimum of 1,000 feet above the highest point within that segment of the glide slope, the runway surface, or the missed approach course, whichever attains the highest altitude.

7.0 MINIMUMS.

For close parallel procedures, only straight-in precision minimums apply.

8.0 MISSED APPROACH SEGMENT.

Volume 3 chapter 3 applies, except as stated in this appendix. Missed approach procedures for close parallels shall specify a turn as soon as possible after reaching a minimum of 400 feet above the touchdown zone, and diverge at a minimum of 45°. The turn points specified for the two parallel procedures should be established at the end of the straight segment minimum of 1.5 NM.
A 45° divergence shall be established by 0.5 NM past the most distant DER. Where an offset localizer is used, the first missed approach turn point shall be established so that the applicable flight track radius (table 5 in Volume 1, chapter 2), constructed in accordance with Volume 1, chapter 2, section 7, for the fastest category aircraft expected to utilize the offset course, shall not be less than 700 feet from the NTZ.

8.1 NTZ.

The NTZ shall be continued into the missed approach segment, as defined in paragraph 4.3 of this appendix (see figure A3-1).

8.2 NOZ.

The NOZ shall be continued into the missed approach segment, as defined in paragraph 4.4 of this appendix (see figure A3-1).

APPENDIX 4. OBSTACLE ASSESSMENT SURFACE EVALUATION FOR SIMULTANEOUS PARALLEL PRECISION OPERATIONS

1.0 BACKGROUND.

One of the major aviation issues is the steady increase in the number and duration of flight delays. Airports have not been able to expand to keep pace with traffic growth. The Federal Aviation Administration (FAA) has taken a variety of measures to increase airport capacity. These include revisions to air traffic control procedures; addition of landing systems, taxiways and runways; and application of new technology. The precision radar monitor (PRM) program is one of these new initiatives. PRM is an advanced radar monitoring system intended to increase the use of multiple, closely-spaced parallel runways in instrument meteorological conditions (IMC) weather by use of high resolution displays with alert algorithms and higher aircraft position update rate. Monitor controllers are required for both standard and closely-spaced runway separations. The primary purpose of radar monitoring during simultaneous, independent approach operations is to ensure safe separation of aircraft on the parallel approach courses. This separation may be compromised if an aircraft blunders off course toward an aircraft on the adjacent approach. For close parallel operations (3,400 feet but less than 4,300 feet) and for standard parallel operations (4,300 feet and above), the radar monitoring allows controllers to direct either aircraft off the approach course to avoid a possible collision. Resolution of a blunder is a sequence of events: the monitor alerts and displays the blunder, the controllers intervene, and the pilots comply with controller instructions; thus, increasing the operational safety, flyability, and airport capacity.

2.0 DEFINITIONS.

2.1 COURSE WIDTH (CW).

The angular course deviation required to produce a full scale (±) course deviation indication of the airborne navigation instrument. This width is normally tailored to a parameter of not greater than ±3°. For precision runways longer than 4,000 feet, a linear sector width parameter of ±350 feet each side of centerline at RWT applies. Few Category I localizers operate with a course sector width less than 3° (±1½°). Tailored width may be determined by the formula:

$$W = \text{ArcTan}\left(\frac{350}{D}\right) \quad \text{Total Course Width at RWT} = 2 \times W$$

Where: W = Half Width (in degrees) at RWT

D = Distance from localizer antenna to RWT (in feet)

2.2 PARALLEL APPROACH OBSTRUCTION ASSESSMENT (PAOA).

An examination of obstruction identification surfaces, in addition to the ILS TERPS surfaces, in the direction away from the NTZ and adjacent parallel ILS runway, into which an aircraft on an early ILS breakout could fly.

2.3 PARALLEL APPROACH OBSTRUCTION ASSESSMENT SURFACES (PAOAS).

PAOA assessment surfaces for identifying obstacles that may impact simultaneous precision operations.

2.4 PARALLEL APPROACH OBSTRUCTION ASSESSMENT SURFACE PENETRATION.

One or more obstructions that penetrate the PAOAS.

2.5 PARALLEL APPROACH OBSTRUCTION ASSESSMENT CONTROLLING OBSTRUCTION (PAOACO).

The obstruction within the boundaries of the PAOAS which constitutes the maximum penetration of that surface.

2.6 NO TRANSGRESSION ZONE (NTZ).

See Volume 3, appendix 3, paragraph 4.3.

2.7 NORMAL OPERATIONAL ZONE (NOZ).

See Volume 3, appendix 3, paragraph 4.4.

3.0 GENERAL.

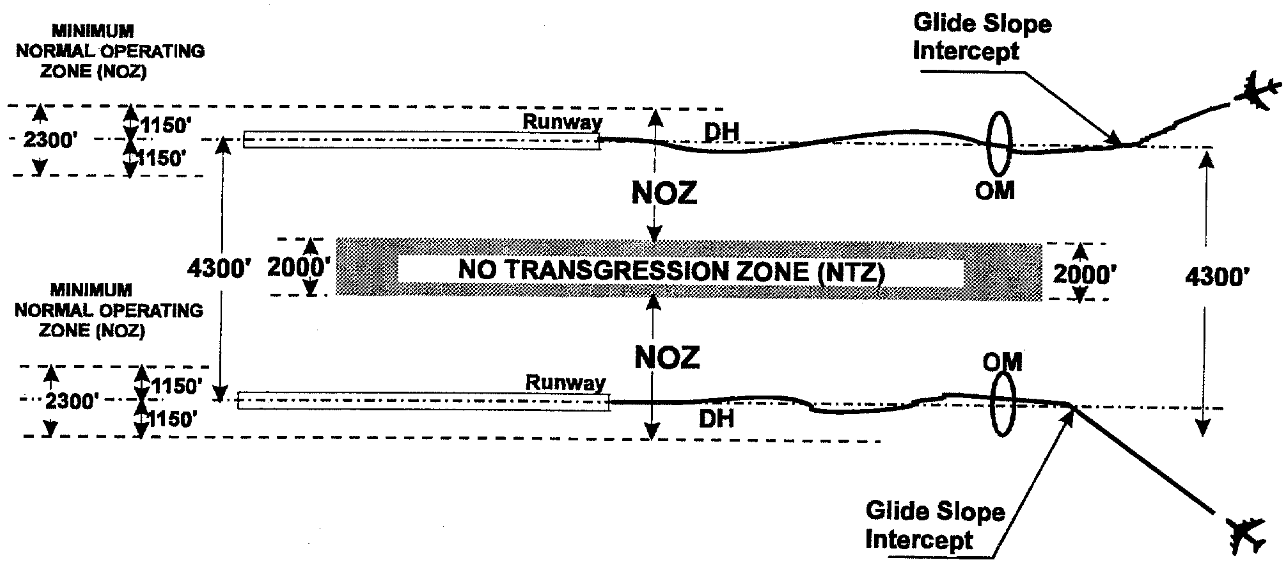
This order characterizes criteria used during the interim test phase of evaluating close parallel operations where early turnout obstacle assessments were accomplished by contractual means using terrestrial photometric techniques combined with survey methods of surface evaluation. This assessment technique is recommended for future evaluations of all independent simultaneous parallel approach operations. Facility information (glidepath angle (GPA), threshold crossing heights (TCH), touchdown zone elevation (TDZE), threshold elevations, etc.) may be obtained from air traffic planning and automation, flight procedures offices, and/or the systems management organizations for the regions in which independent simultaneous parallel operations are planned.

3.1 PARALLEL RUNWAY SIMULTANEOUS ILS APPROACHES.

The procedures for airports with multiple parallel runways must ensure that an aircraft approach on one runway is safely separated from those approaching the adjacent parallel runway. An example of such procedures is depicted in figure A4-1. Aircraft are directed to the two intermediate segments at altitudes which differ by at least 1,000 feet. Vertical separation is required when lateral separation becomes less than 3 nautical miles (NM), as aircraft fly to intercept and stabilize on their respective localizers (LOC). This 1,000-foot vertical separation is maintained until aircraft begin descent on the glidepath.

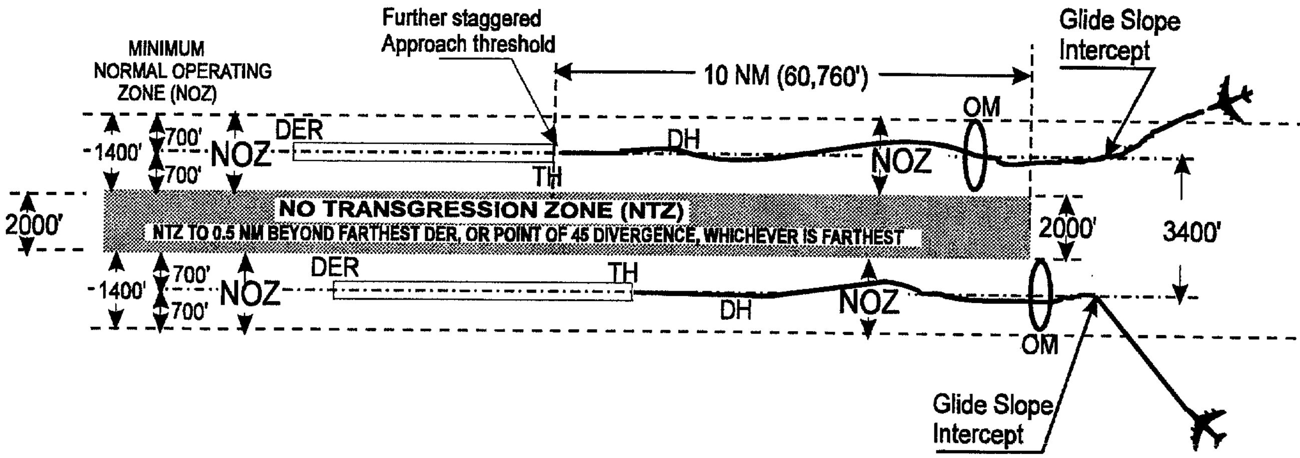
3.1.1 **When lateral radar separation is less than the 3 NM** and the 1,000-foot altitude buffer is lost, the aircraft must be monitored on radar. The controllers, on separate and discrete frequencies, will observe the parallel approaches, and if an aircraft blunders from the NOZ into a 2,000-foot NTZ, the monitor controller can intervene so that threatened aircraft on the adjacent approach are turned away in time to prevent a possible encounter. This maneuver, on the part of the threatened aircraft, is termed a "breakout" because the aircraft is directed out of the approach stream to avoid the transgressor aircraft. A controller for each runway is necessary so that one can turn the transgressing aircraft back to its course centerline while the other directs the breakout (see figure A4-1).

Figure A4-1. Simultaneous precision parallel Runway Approach Zones



3.1.2 **The 2,000-foot NTZ**, flanked by two equal NOZ's, provides strong guidance to the monitor controller and maneuvering room for the aircraft to recover before entering the adjoining NOZ. Aircraft are required to operate on or near the approach course within the limits of the NOZ. If an aircraft strays into the NTZ or turns to a heading that will take it into the NTZ, it is deemed a threat to an aircraft on the adjacent course and appropriate corrective action or breakout instructions are issued (see figure A4-2).

Figure A4-2. Simultaneous ILS No Transgression Zone and Normal Operating Zone



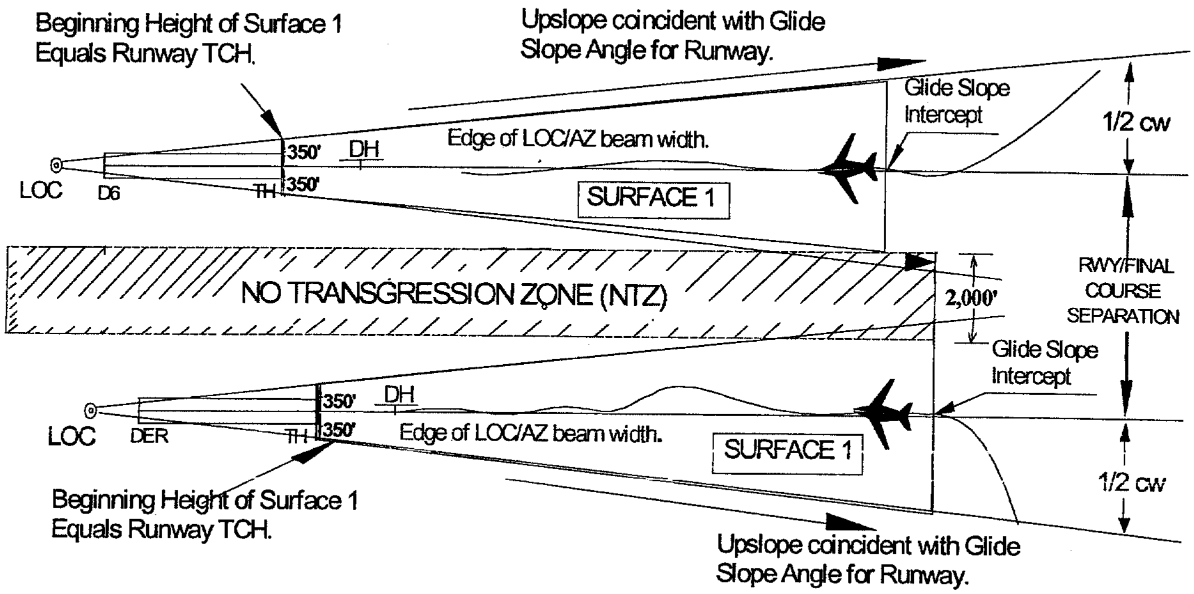
4.0 PAOA EVALUATION.

The PAOA evaluation shall be conducted to identify penetrating obstacles as part of a coordinated assessment for all independent simultaneous approach operations to parallel ILS/MLS runways. In these criteria, ILS glidepath/localizer terms are synonymous to and may be used interchangeably with MLS elevation glidepath/azimuth (GP/AZ) terms. The surface dimensions for the obstacle assessment evaluation are defined as follows:

4.1 SURFACE 1.

A final approach course descent surface which is coincident with the glide slope/glidepath (GS/GP) beginning at runway threshold with the width point abeam the threshold 350 feet from runway centerline opposite the NTZ, with lateral boundaries at the outer edge of the LOC/AZ CW, and ending at the farthest GS/GP intercept (see figure A4-3).

Figure A4-3. Final Approach Descent Surface 1



1/2 CW = Perpendicular distance from runway/extended C_L to edge of course beam width.

1/2 CW = Distance from Threshold in feet along C_L X TAN (1/2 Course Beam Angle) + 350'.

OR

1/2 CW = Distance from LOC/AZ Antenna in feet along C_L X TAN $\frac{\text{(LOC/AZ Beam Angle).}}{2}$

Suface 1 Height – Distance from TH in feet along C_L X TAN of the GS/GP angle + TCH.

4.1.1 **Length.** Surface 1 begins over the runway threshold at a height equal to the TCH for the runway, and continues outward and upward at a slope that is coincident with the GS/GP, to its ending at the GS/GP intercept point.

4.1.2 **Width.** Surface 1 has a width equal to the lateral dimensions of the LOC/AZ course width. The Surface 1 half-width (see figure A4-2) is calculated using the following formula:

$$\frac{1}{2}W = A \times Tan\left(\frac{B}{2}\right) + 350$$

Where W = Width of Surface 1

A = Distance from RWT measured parallel to course

B = Course Width Beam Angle

OR

$$\frac{1}{2}W = L \times Tan\left(\frac{B}{2}\right)$$

Where W = Width of Surface 1

L = Distance from Azimuth antenna (in feet)

B = Course Width Beam Angle

4.1.3 **Surface 1 Height.** Surface height at any given centerline distance (d), may be determined in respect to threshold elevation, by adding the TCH to the product of centerline distance in feet from threshold times the tangent of the GS/GP angle.

$$h1 = [d \times Tan(GPA)] + TCH$$

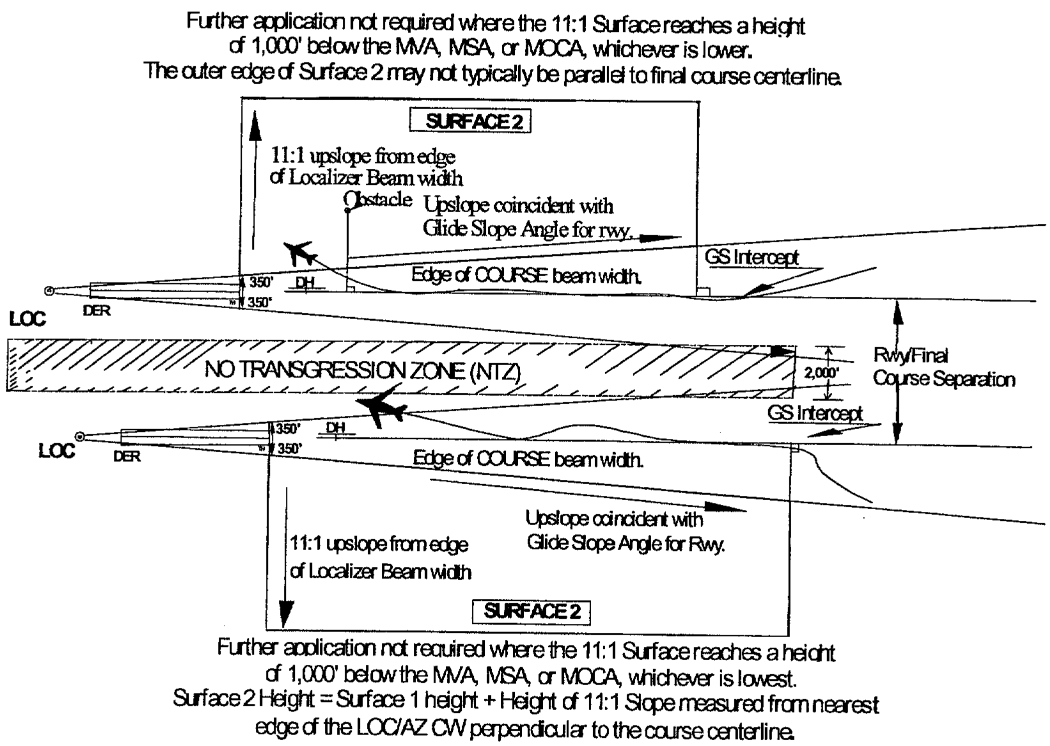
Where: h1 = surface 1 height above ASBL

4.2 **SURFACE 2.**

4.2.1 **Length.** Same as paragraph 4.1.1.

4.2.2 **Width and Height.** Surface 2 shares a common boundary with the outer edge of surface 1 on the side opposite the NTZ, and slopes upward and outward from the edge of the descent surface 1 at a slope of 11:1, measured perpendicular to the LOC/AZ extended course centerline. Further application is not required when the 11:1 surface reaches a height of 1,000 feet below the MVA, MSA, or MOCA, whichever is lowest (see figure A4-4).

Figure A4-4. Parallel Approach Obstacle Assessment Surface 2



4.3 **SURFACE 3 (CATEGORY I).**

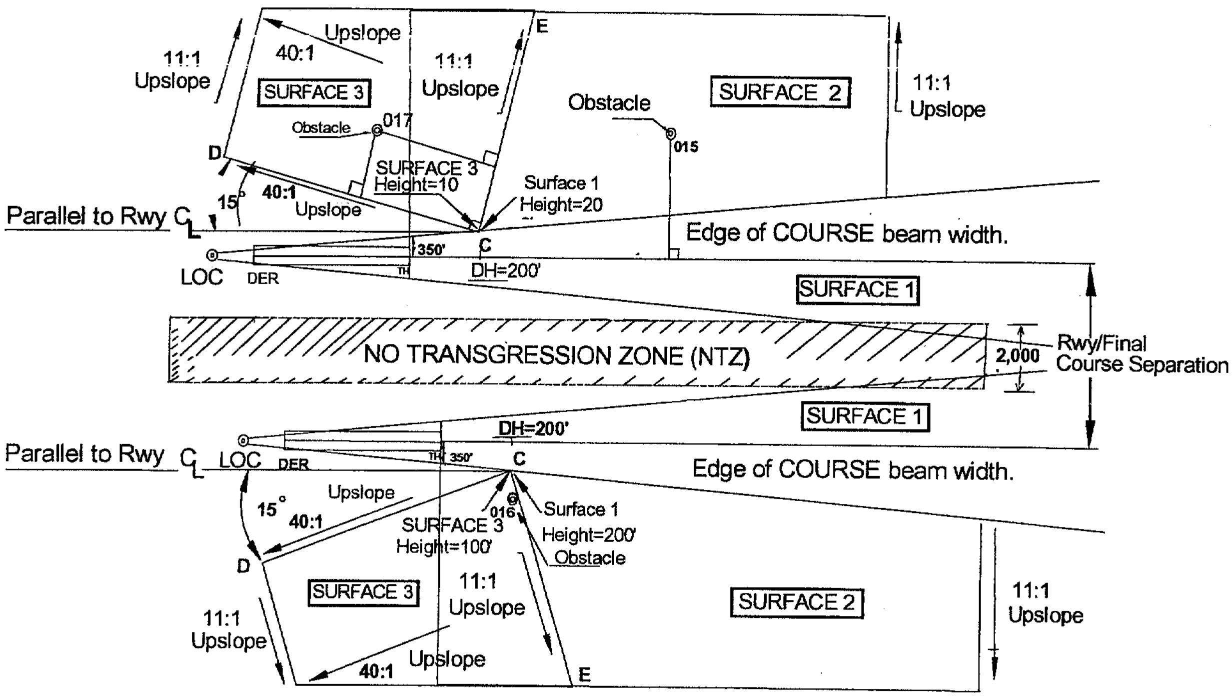
4.3.1 **Length.** For category I operations, surface 3 begins at the point where surface 1 reaches a height of 200 feet above the TDZE and extends to the point the 40:1 and 11:1 slopes reach a height of 1,000 feet below the MVA, MSA, or MOCA, whichever is lowest.

4.3.2 **Width.** From the beginning point, the edge of surface 3 area splays at a 15° angle from a line parallel to the runway centerline.

4.3.3 **Surface Height.** Surface 3 begins at a height of 100 feet above TDZE (100 feet lower than surface 1). The surface rises longitudinally at a 40:1 slope along the 15° splay line CD while continuing laterally outward and upward at an 11:1 slope (line CE is perpendicular to the 15° splay line CD). Further application is not required when the 40:1 and 11:1 slopes reach a height of 1,000 feet below the MVA, MSA, or MOCA, whichever is lowest (see figure A4-5).

Figure A4-5. CAT I Missed Approach Early Breakout Parallel Approach Obstacle Assessment Surface 3.

The outer edges of Surfaces 2 or 3 may not typically be parallel to each other or runway C_L. Further application not required when the 40:1 and 11:1 surfaces reach a height of 1,000' below MVA, MSA or MOCA, whichever is lower.



Further application not required when the 40:1 and 11:1 surfaces reach a height of 1,000' below MVA, MSA, or MOCA, whichever is lower. Surface 3 Height = Height of 11:1 Slope measured (fr. Obs.) perpendicular to Line CD + Height of 40:1 Slope measured (fr. Obs.) perpendicular to Line CE + 100 feet.

4.4 **SURFACE 4 (CATEGORY II).**

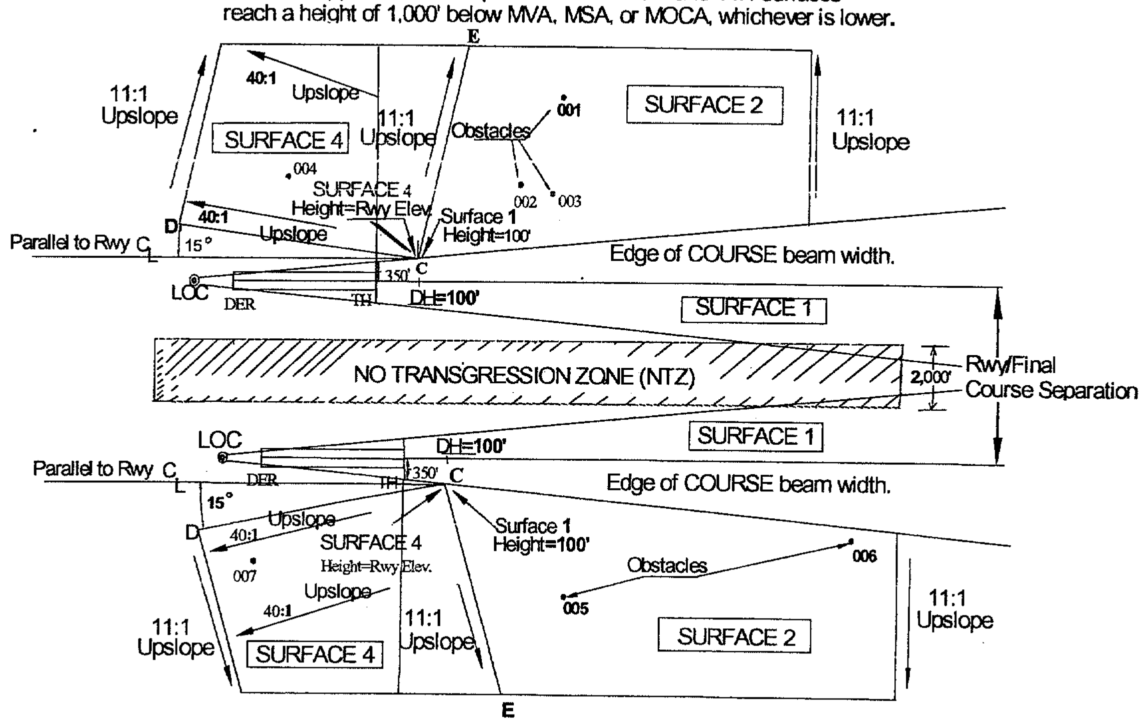
4.4.1 **Length.** Surface 4 begins at the point where surface 1 reaches a height of 100 feet above the runway TDZE and extends to the point 40:1 and 11:1 slopes reach a height of 1,000 feet below the MVA, MSA, or MOCA, whichever is lowest.

4.4.2 **Width.** From the point of beginning, the edge of surface 4 area splays at a 15° angle from a line parallel to the runway centerline.

4.4.3 **Surface Height.** Surface 4 begins at the point where surface 1 reaches a height of 100 feet above the runway TDZE and rises longitudinally at a 40:1 slope along the 15° splay line CD, while continuing laterally outward and upward at an 11:1 slope (line CE is perpendicular to the 15° splay line CD). Further application is not required when the 40:1 and 11:1 slopes reach a height of 1,000 feet below the MVA, MSA, or MOCA, whichever is lowest (see figure A4-6).

Figure A4-6. CAT II Missed Approach Early Breakout Parallel Approach Obstacle Assessment Surface 4

The outer edges of Surface 2 or 4 may not typically be parallel to each other or runway C_L. Further application not required when the 40:1 and 11:1 surfaces reach a height of 1,000' below MVA, MSA, or MOCA, whichever is lower.



Further application not required when the 40:1 and 11:1 surfaces reach a height of 1,000' below MVA, MSA, or MOCA, whichever is lower. Surface 4 Height = Height of 11:1 Slope measured (fr. Obs.) perpendicular to Line CD + Height of 40:1 Slope measured (fr. Obs.) perpendicular to Line CE.

4.5 **ESTABLISH A LATITUDE-LONGITUDE LIST** for all obstacles penetrating PAOA surfaces 2, 3, and 4. Identify locations of surface penetration within the surface areas (see figures A4-3, A4-4, and A4-5).

4.6 **PARALLEL OPERATIONS APPLICATION REQUIREMENTS.**

PAOA obstacle penetrations shall be identified and, through coordinated actions of those affected, considered for electronic mapping on controller radar displays. If possible, penetrations should be removed by facilities considering independent simultaneous approach operations to parallel precision runways. Where obstacle removal is not feasible, air traffic operational rules shall be established to avoid obstacles. If a significant number of penetrations occur, a risk assessment study shall be required to provide guidance as to whether independent simultaneous ILS/MLS operations to parallel runways should be approved or denied.

APPENDIX 5.

THRESHOLD CROSSING HEIGHT

GROUND POINT OF INTERCEPT

RUNWAY POINT OF INTERCEPT

TCH/GPI/RPI CALCULATION

The following spreadsheets are a part of this appendix and can be found on the internet "http:\\terps.faa.gov"

Figure A5-1. Non-Radar Precision TCH/GPI/RPI

Figure A5-2. Precision Approach Radar (PAR) (Scanning Radar)

Figure A5-3. Precision Radar TCH/GPI/RPI

Version 1.0

Figure A5-1. Non-Radar Precision TCH/GPI/RPI

1,016.00	A=Distance (ft) from GS antenna to RWT
100.00	a=RWT elevation (MSL)
98.00	c=Elevation (MSL) of runway crown at RPI/TDP
90.00	h=ILS antenna base elevation (MSL)
107.20	p=Phase center (MSL) of elevation antenna
3.00	e=Glidepath angle

STEP 1: **CALCULATE OR SPECIFIY TCH**

51.25 ILS (smooth terrain) $\tan(e) \times A - (a - c)$

43.25 ILS (rapidly dropping terrain) $\tan(e) \times A - (a - h)$

60.45 MLS $\tan(e) \times A + (p - a)$

50.00 LAAS/WAAS Specify TCH

STEP 2: CALCULATE GPI

977.84 ILS (smooth terrain)

825.19 ILS (rapidly dropping terrain) $\frac{TCH}{\tan(e)}$

1,153.38 MLS

954.06 LAAS/WAAS

STEP 3: CALCULATE RPI

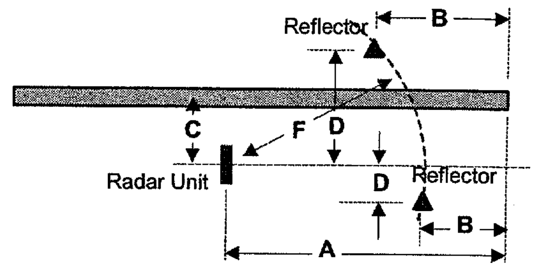
1,016.00 ILS (smooth terrain)

863.35 ILS (rapidly dropping terrain) $\frac{TCH + (a - c)}{\tan(e)}$

1,191.55 MLS

992.22 LAAS/WAAS

Figure A5-2.
Precision Approach Radar (PAR)
(Scanning Radar)



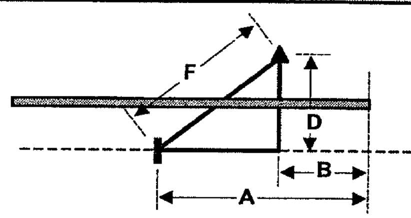
Version 1.0

ELEVATIONS (MSL):		DISTANCES (FT):	
Threshold [a]:	100	AZ antenna to threshold [A]:	4500
Touchdown Reflector [b]:	105	TD reflector to threshold [B]:	750
RWY Crown in TDZE [c]:	100.7	AZ antenna to centerline [C]:	450
RPI (if known) [d]:	100.5	TD reflector to CLA line [D]:	475
Glidepath Angle [e]:	3	RWY gradient (if required) [E]:	0.00023333

STEP 1: Determine distance from AZ antenna to TD reflector [F].

3,779.96

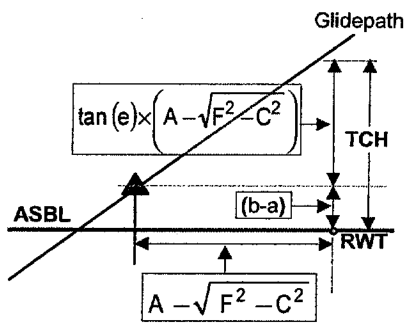
$$F=\sqrt{(A-B)^2+D^2}$$

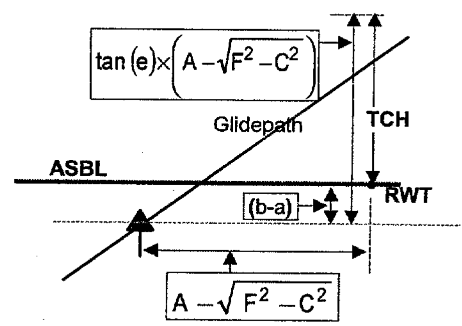


STEP 2: Determine threshold crossing height [TCH].

44.14

$$TCH=\tan(e)\times\left(A-\sqrt{F^2-C^2}\right)+(b-a)$$





STEP 3: Determine ground point of intercept [GPI].

842.32

$$GPI=\frac{TCH}{\tan(e)}$$

STEP 4: Determine runway point of intercept [RPI].

[d] known

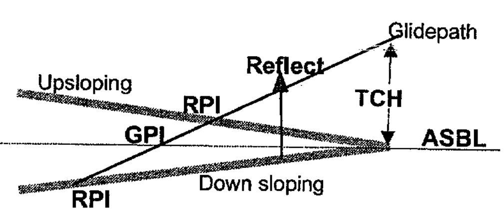
832.78

$$RPI=\frac{TCH-(d-a)}{\tan(e)}$$

[d] unknown

838.59

$$RPI=\frac{TCH}{\tan(e)+E}$$ for up sloping runway



[d] unknown

846.09

$$RPI=\frac{TCH}{\tan(e)-E}$$ for down sloping runway

Version 1.0

Figure A5-3. Precision Radar TCH/GPI/RPI

(Tracking Radar)

100.00	a=RWT elevation (MSL)
98.00	c=Elevation (MSL) of runway crown at RPI/TDP
3.00	e=Glidepath angle

STEP 1: **SPECIFIY TCH**

50.00 <== TCH

STEP 2: **CALCULATE GPI**

954.06 <== GPI

$$\frac{TCH}{\tan(e)}$$

STEP 3: **CALCULATE RPI**

992.22 <== RPI

$$\frac{TCH+(a-c)}{\tan(e)}$$

FAA ORDER **8260.3B**

Army
Navy
Coast Guard
Air Force

TM 95-226
OPNAV Inst. 3722.16C
CG 318
AFMAN 11-226(I)

UNITED STATES STANDARD
FOR
TERMINAL
INSTRUMENT
PROCEDURES
(TERPS)

VOLUME 4

DEPARTURE PROCEDURE CONSTRUCTION

U. S. DEPARTMENT OF TRANSPORTATION

FEDERAL AVIATION ADMINISTRATION

VOLUME 4. TABLE OF CONTENTS

DEPARTURE PROCEDURE CONSTRUCTION

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CHAPTER 1. GENERAL CRITERIA

VOLUME 4. TABLE OF CONTENTS (Continued)

VOLUME 4. TABLE OF CONTENTS (Continued)

CHAPTER 1. GENERAL CRITERIA

1.0 GENERAL.

IFR departure procedures may be designed and published for all runways authorized by the approving authority. For civil procedures, runway/taxiway separations, and airport obstacle free zones (OFZ) must meet the standards in Advisory Circular (AC) 150/5300-13, Airport Design, or appropriate military directives for military procedures for specified departure visibility minimums. Criteria for RNAV-equipped aircraft are provided in Orders 8260.44, Civil Utilization of Area Navigation (RNAV) Departure Procedures, and 8260.40, Flight Management System (FMS) Instrument Procedures Development.

1.1 TERMINOLOGY, ABBREVIATIONS, AND DEFINITIONS.

1.1.1 Climb Gradient (CG).

A climb requirement expressed in ft/NM (gradient greater than 200 ft/NM).

1.1.2 Course.

A specified track measured in degrees from magnetic north.

1.1.3 Dead Reckoning (DR).

The navigation of an airplane solely by means of computations based on airspeed, course, heading, wind direction, speed, ground speed, and elapsed time.

1.1.4 Departure End of Runway (DER).

The end of the runway opposite the landing threshold. It is sometimes referred to as the stop end of runway (SER).

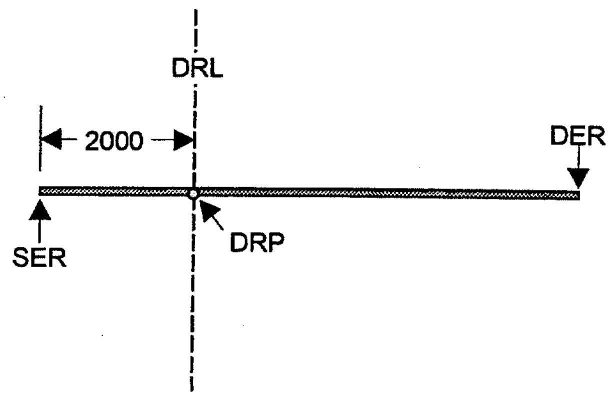
1.1.5 Departure Reference Line (DRL).

An imaginary line of indefinite length perpendicular to runway centerline at the DRP.

1.1.6 Departure Reference Point (DRP).

A point on the runway centerline 2,000 feet from the SER (see figure 1-1).

Figure 1-1. Runway Terms



1.1.7 Departure Route.

A specified course and altitude along a track defined by positive course guidance (PCG) to a clearance limit, fix, or altitude.

1.1.8 Departure Sector.

Airspace defined by a heading or a range of headings for aircraft departure operations.

1.1.9 Diverse Vector Area (DVA).

An area in which a prescribed departure route is not required. Radar vectors may be issued below the minimum vectoring or minimum IFR altitude. It can be established for diverse departure, departure sectors, and/or video map radar areas portraying obstacles and terrain.

1.1.10 Diverse Departure.

A departure without restrictions to the route of flight.

1.1.11 Diverse Departure Evaluation to Establish Sector(s) for Prescribed Departure Routes.

An evaluation of a diverse area to establish an unrestricted area or sector for purposes of publishing departure routes, including multi-turns and legs.

1.1.12 Initial Climb Area (ICA).

An area beginning at the DER to provide unrestricted climb to at least 400 feet above DER elevation.

1.1.13 ICA Baseline (ICAB).

A line at DER, perpendicular to runway centerline, denoting the beginning of the ICA.

1.1.14 ICA End-Line (ICAE). A line at end of ICA perpendicular to the departure course.

1.1.15 Instrument Flight Rules (IFR).

Rules governing the conduct of flight under instrument meteorological conditions.

1.1.16 Instrument Meteorological Conditions (IMC).

Meteorological conditions expressed in terms of visibility, distance from clouds, and ceiling less than the minima specified for visual meteorological conditions.

1.1.17 Obstacle.

Synonymous with natural or man-made obstacles, obstructions, or obstructing terrain.

1.1.18 Obstacle Clearance Surface (OCS).

An inclined surface associated with a defined area for obstacle evaluation.

1.1.19 Obstruction Evaluation Area (OEA).

Areas requiring obstacle evaluation.

1.1.20 Positive Course Guidance (PCG).

A continuous display of navigational data, which enables an aircraft to be flown along a specific course, e.g., radar vector, RNAV, ground-based NAVAID's.

1.1.21 Required Obstacle Clearance (ROC).

Required vertical clearance expressed in feet between an aircraft and an obstruction.

1.1.22 Standard Climb Gradient (SCG).

Departure and missed approach obstacle clearance is based on the assumption that an aircraft will climb at a gradient of at least 200 feet per NM. This is the standard climb gradient.

1.1.23 Start End of Runway (SER).

The beginning of the takeoff runway available.

1.1.24 Takeoff Runway Available (TORA).

The length of runway declared available and suitable for satisfactory takeoff run requirements.

1.1.25 Visual Flight Rules (VFR).

Rules that govern the procedures for conducting flight under visual conditions.

1.1.26 Visual Meteorological Conditions (VMC).

Meteorological conditions expressed in terms of visibility, distance from clouds, and ceiling equal to or better than specified minima.

1.1.27 Visual Climb Area (VCA).

Areas around the airport reference point (ARP) to develop a VCOA procedure.

1.1.28 Visual Climb over Airport (VCOA).

Option to allow an aircraft to climb over the airport with visual reference to obstacles to attain a suitable altitude from which to proceed with an IFR departure.

1.2 DEPARTURE CRITERIA APPLICATION.

Evaluate runways for IFR departure operations by applying criteria in the sequence listed below (paragraphs 1.2.1 through 1.2.3).

1.2.1 **Perform a diverse departure evaluation** to each runway authorized for IFR takeoff. Diverse departure is authorized if the appropriate OCS is clear. If the OCS is penetrated, consider development of departure sectors and/or climb gradients.

1.2.2 **Develop departure routes** where obstacles prevent diverse departure operations.

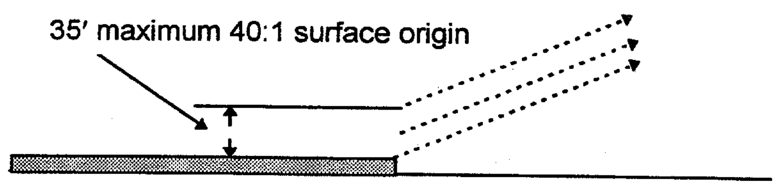
1.2.3 **Develop a VCOA procedure** where obstacles more than 3 statute miles from DER require climb gradients greater than 200 ft/NM (see chapter 4).

1.2.4 **At locations served by terminal radar**, air traffic control may request development of diverse vector areas to aid in radar vectoring departure traffic (see chapter 2, paragraph 2.3).

1.3 DEPARTURE OCS APPLICATION.

The OCS begins at the DER at DER elevation. EXCEPTION: Adjust the origin height up to 35 feet above DER as necessary to clear existing obstacles (see figure 1-2). Evaluate proposed obstacles assuming the OCS origin is at DER elevation.

Figure 1-2. OCS Starting Elevation



1.3.1 Low, Close-In OCS Penetrations.

Do not publish a CG to a height of 200 feet or less above the DER elevation. Annotate the location and height of any obstacles that cause such climb gradients.

1.3.2 Calculating OCS Height.

The OCS height is based on the distance measured from the OCS origin along the shortest distance to an obstacle within the segment.

1.3.2 a. **Primary Area.** The OCS slope is 40:1. Use the following formula to calculate the OCS height:

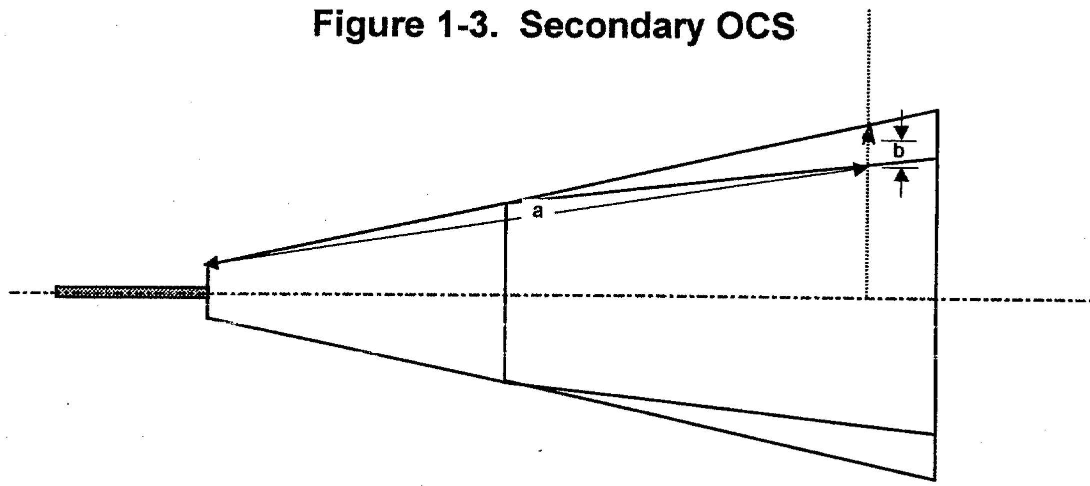
$$h_{OCS} = \frac{d}{40} + e$$

where d=shortest distance (ft) from the OCS origin to the obstacle
e=OCS origin elevation

$$\text{Example:} \quad \frac{8923}{40} + 1221 = 1444.08 \text{ ft}$$

1.3.2 **b. Secondary Area.** (Applicable only when PCG is identified.) The OCS slope is 12:1. The secondary OCS elevation is the sum of the 40:1 OCS rise (a) in the primary area to a point the obstacle is perpendicular to the departure course, and the secondary OCS rise (b) from the edge of the primary OCS to the obstacle (see figure 1-3).

Figure 1-3. Secondary OCS



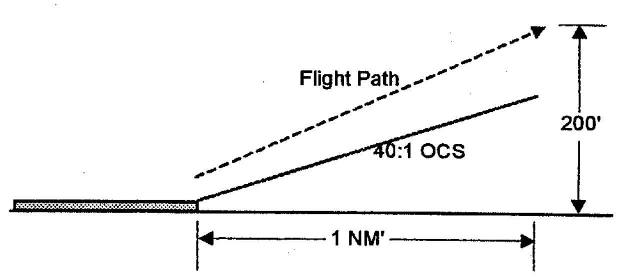
$$h_{SECONDARY} = \frac{a}{40} + \frac{b}{12}$$

Example: $$\frac{21191}{40} + \frac{318}{12} = 556.28$$

1.4 CLIMB GRADIENTS.

Departure procedure obstacle clearance is based on a minimum climb gradient performance of 200 ft/NM (see figure 1-4).

Figure 1-4. Standard Climb Gradient



1.4.1 Calculating Climb Gradients to Clear Obstacles.

Climb gradients in excess of 500 ft/NM require approval of the Flight Standards Service or the appropriate military authority. Calculate climb gradients using the following formula::

Standard Formula

$$CG = \frac{O-E}{0.76\ D}$$

DoD Option*

$$CG = \frac{(48D+O)-E}{D}$$

where O = obstacle MSL elevation
E = climb gradient starting MSL elevation
D = distance (NM) from DER to the obstacle

Examples:

$$\frac{2049-1221}{0.76 \times 3.1} = 351.44$$

Round to 352 ft/NM

$$\frac{(48 \times 3.1 + 2049) - 1221}{3.1} = 315.10$$

Round to 316 ft/NM

* For use by military aircraft only. Not for civil use.

1.4.2 Calculating the CG Termination Altitude.

When the aircraft achieves an altitude that provides the required obstacle clearance, the CG restriction may be lifted. This altitude is called the "climb to" altitude (A). Calculate the climb-to altitude using the following formula:

$$A = E + (CG \times D)$$

Example: $1221 + (352 \times 3.1) = 2312.20$ Round to 2400

1.4.3 Climb Gradients to Altitudes for Other than Obstacles, i.e., ATC.

Calculate the climb gradient to the stated "climb to" altitude using the following formula where (D) is the distance from the beginning of the climb to the point where the altitude is required:

$$CG = \frac{A-E}{D}$$

Example: $\frac{3000-1221}{5} = 355.8$ round to 356 ft/NM

NOTE: The climb gradient must be equal to or greater than the gradient required for obstacles along the route of flight.

1.4.4 Multiple Climb Gradients Application.

Do not publish a number of different gradients for a series of segments. Consider only one climb gradient, which is the most efficient gradient to represent the entire length of the climb gradient distance that encompasses all of the climb gradients required.

1.4.5 Limiting TORA to Reduce Climb Gradient.

Limiting the available length of the departure runway during takeoff is an option that can be used to reduce departure climb gradients. Use of this option requires approval of FAA Flight Standards or the appropriate military authority. Use the following formula to determine the TORA for a given desired climb gradient (DCG):

$$TORA = L - \left(\frac{A}{DCG} - \frac{A}{CG}\right) 6076.11548$$

Where A=Altitude above DER elevation where CG ends
CG=Required climb gradient before adjustments
DCG=Desired climb gradient
L=Full length of runway available for departure before adjustments

$$\text{Example:} \quad 10000 - \left(\frac{1000}{250} - \frac{1000}{300}\right) 6076.11548 = 5949.26'$$

1.4.6 Effect of DER-To-Obstacle Distance.

1.4.6 a. **Where obstacles 3 statute miles or less** from the DER penetrate the OCS:

1.4.6 a. (1) **Publish** a note identifying the obstacle(s) type, location relative to DER, AGL height, and MSL elevation, and

1.4.6 a. (2) **Publish** standard takeoff minimums with a required CG to a specified altitude, and

1.4.6 a. (3) **Publish** a ceiling and visibility to see and avoid the obstacle(s), and/or

1.4.6 a. (4) **Develop** a specific textual or graphic route to avoid the obstacle(s).

NOTE: Where low, close-in obstacles result in a climb gradient to an altitude 200 feet or less above DER elevation, only paragraph 1.4.6a(1) applies.

1.4.6 b. **Where obstacles more than 3 statute miles** from the DER penetrate the OCS:

1.4.6 b. (1) **Publish** standard takeoff minimums with a required CG to a specified altitude, and

1.4.6 **b. (2) Develop** a VCOA procedure to an altitude that will provide obstacle clearance without a CG, and/or

1.4.6 **b. (3) Develop** a specific textual or graphic departure route to avoid the obstacle(s).

1.5 CEILING AND VISIBILITY.

1.5.1 Ceiling.

Specify a ceiling value equal to the height of the obstruction above the airport elevation rounded to the next higher 100-foot increment.

1.5.2 Visibility.

Specify a visibility value equal to the distance measured directly from the DER to the obstruction rounded to the next higher reportable value. Limit the visibility to a distance of 3 statute miles.

1.6 INITIAL CLIMB AREA (ICA).

The ICA is an area centered on the runway centerline extended used to evaluate obstacle clearance during the climb to 400 feet above DER (minimum climb gradient 200 ft/NM).

1.6.1 ICA Terms.

1.6.1 a. ICA baseline (ICAB). The ICAB is a line extending perpendicular to the runway centerline ± 500 at DER. It is the origin of the ICA (see figure 1-5).

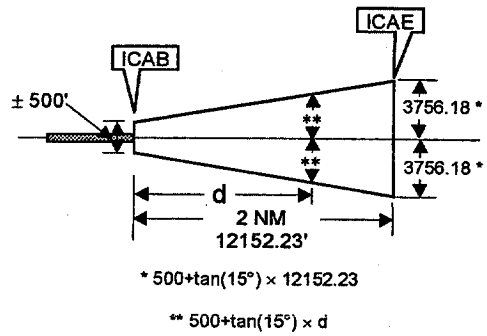
1.6.1 b. ICA end-line (ICAE). The ICAE is a line at the end of the ICA perpendicular to the runway centerline extended. The splay of 15° and length of the ICA determine its width (see figure 1-5).

1.6.2 Area.

1.6.2 a. Length. The ICA length is normally 2 NM, measured from the ICAB to the ICAE along runway centerline extended. It may be less than 2 NM in length for early turns by publishing a climb gradient, or a combination of climb gradient and reduction in TORA. The ICA may be extended beyond 2 NM to maximum length of 10 NM. A specified altitude (typically 400' above DER) or the interception of PCG route must identify the ICAE.

1.6.2 **b. Width.** The ICA origin is 1,000 feet (± 500 perpendicular to runway centerline) wide at the DER. The area splays outward at a rate of 15° relative to the departure course (normally runway centerline).

Figure 1-5. ICA



1.6.2 **c. OCS.** The OCS originates at the ICAB, normally at DER elevation (see paragraph 1.3). Apply the OCS by measuring the shortest distance from the ICAB to the obstacle and evaluate per paragraph 1.3. The MSL elevation of the ICAE is calculated using the following formula:

MSL ICAE elevation=a+b+303.81

where a=DER elevation
b=OCS origin height above DER elevation
(nominally 0)

Example: ICAE elevation=987.24+0+303.81=1291.05

CHAPTER 2. DIVERSE DEPARTURE

2.0 GENERAL.

Evaluate diverse "A" and "B" areas to a distance of 25 NM for nonmountainous areas (see figure 2-1) and 46 NM for mountainous areas. If obstacles do not penetrate the OCS, unrestricted diverse departure may be authorized; publish standard takeoff minimums.

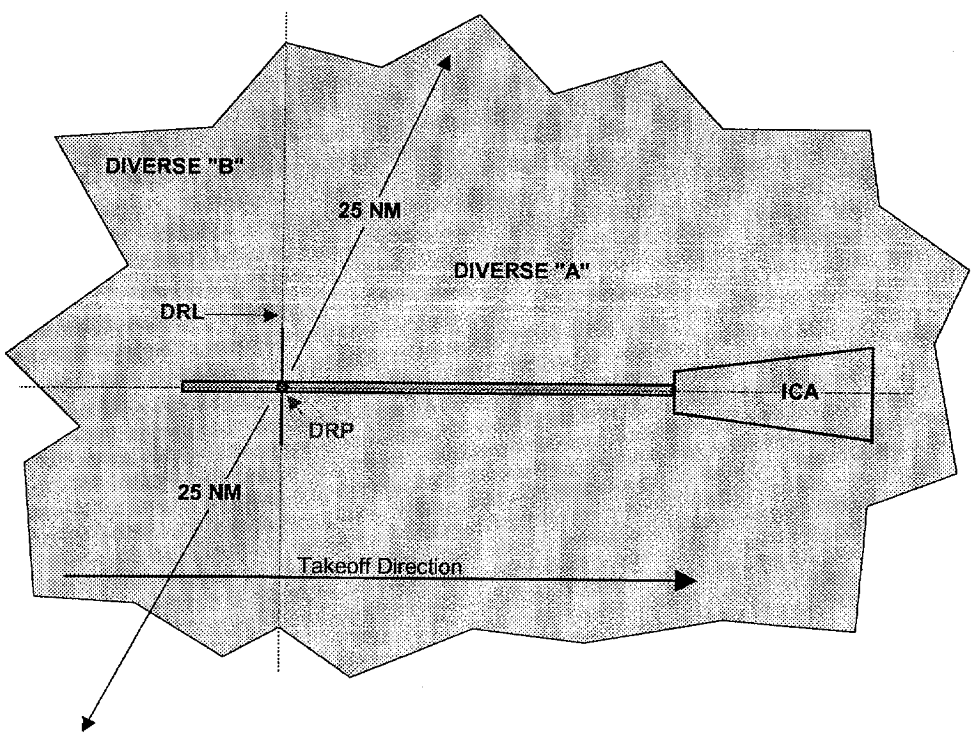
2.1 AREA. The diverse departure evaluation covers three areas:

Initial Climb Area. See chapter 1, paragraph 1.6.

Diverse A. All areas on the DER side of the DRL.

Diverse B. All areas on the SER side of the DRL.

Figure 2-1. Diverse "A" and "B" Areas



2.1.1 Initial Climb Area (ICA).

Evaluate the ICA under paragraph 1.6.

2.1.2 Diverse "A" Area.

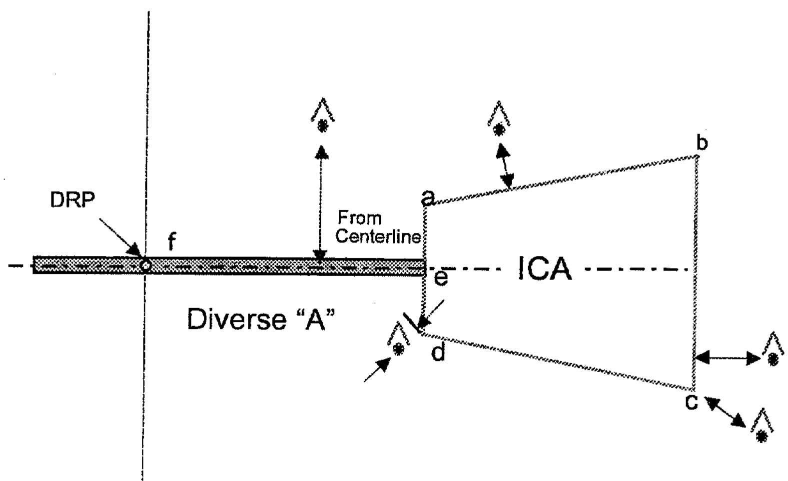
Calculate the height of the OCS at any given location in the diverse "A" area by measuring the distance from the obstacle to the closest point on the centerline of the runway between the DRP and DER, or the closest point on ICA boundary lines as appropriate (see figure 2-2). The beginning OCS elevation is equal to the MSL elevation of the ICAE.

$$h=a+\frac{d}{40}$$

where h=OCS MSL elevation at obstacle
d=distance (ft) from obstacle to closest point
a=ICAE MSL elevation

Example: $h=1309.77+\frac{18002.33}{40}=1759.83$

Figure 2-2. Diverse "A" Area Evaluation



2.1.3 Diverse "B" Area.

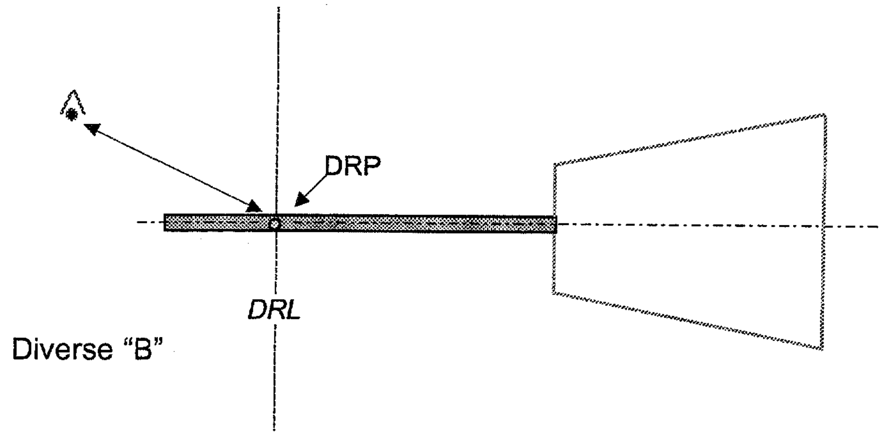
Evaluate obstacles in the Diverse "B" area by measuring the distance in feet from the obstacle to the DRP (see figure 2-3). Calculate the OCS MSL elevation at the obstacle using the following formula:

$$h=\frac{d}{40}+(b+400)$$

where h=OCS MSL elevation at obstacle
d=distance (ft) from obstacle to DRP
b=Airport MSL elevation

Example: $h=\frac{8500}{40}+(1283.22+400)=1895.72$

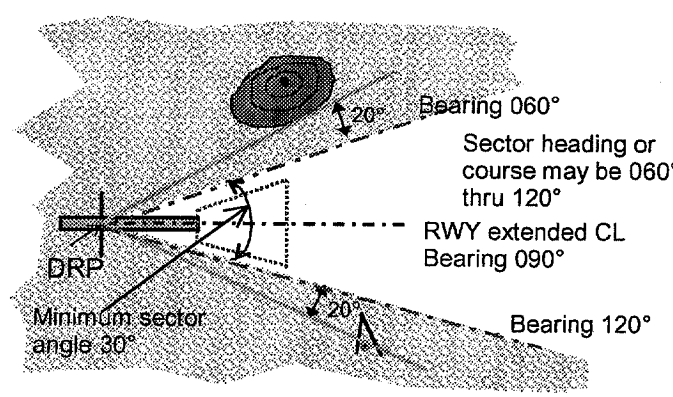
Figure 2-3. Diverse "B" Area



2.2 DEPARTURE SECTORS.

Where OCS penetrations prevent unrestricted diverse departure, consider constructing sectors within the diverse areas where departure flight is prohibited. Departure instructions must assure the aircraft will maneuver clear of the prohibited sector boundaries. Separate sector boundaries from obstacles via a buffer established by the 20° splay from the DRP. The minimum angle between sector boundaries is 30°. The ICA must be protected at all times (see figure 2-4).

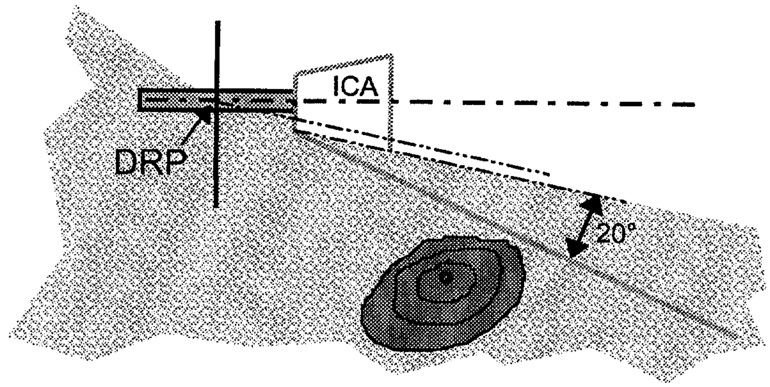
Figure 2-4. Minimum Sector Area



2.2.1 Boundary Based on the ICA.

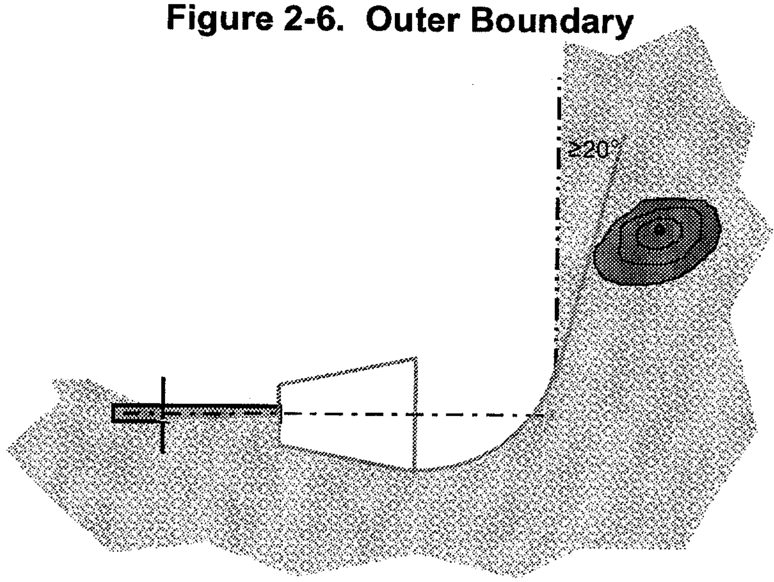
When the 20° splay from the DRP cuts across the ICA, construct a line 20° relative to the side of the ICA. To protect the ICA, no obstacle may lie inside this line (see figure 2-5).

Figure 2-5. Boundary Based on ICA



2.2.1 **a. Outer Boundary involving a Turn.** Locate the turn point on runway centerline (extended) and establish the ICAE. Construct the outer boundary from the ICAE, using table 1-1 for selection of the outer boundary radius. Construct a line from the obstacle tangent to the outer boundary radius. Establish the outer boundary buffer 20° from this line on the maneuvering side. Begin the 20° buffer at the tangent point where the obstacle line intercepts the arc (see figure 2-6).

Figure 2-6. Outer Boundary



2.2.2 **Defining Sector Boundaries.**

Construct boundaries to define each sector. Sector boundaries originate at the DRP, or are defined tangentially from the outer boundary radius (see figure 2-7A). Define and publish sector boundaries by reference to aircraft magnetic headings. Sector "headings" shall be equivalent to the magnetic bearing of the sector boundaries from their origins.

2.2.3 **Sector Limitations.**

2.2.3 a. **The maximum turn** from the takeoff runway in any one direction is 180° relative to takeoff runway heading.

Figure 2-7A. Sector Limitations

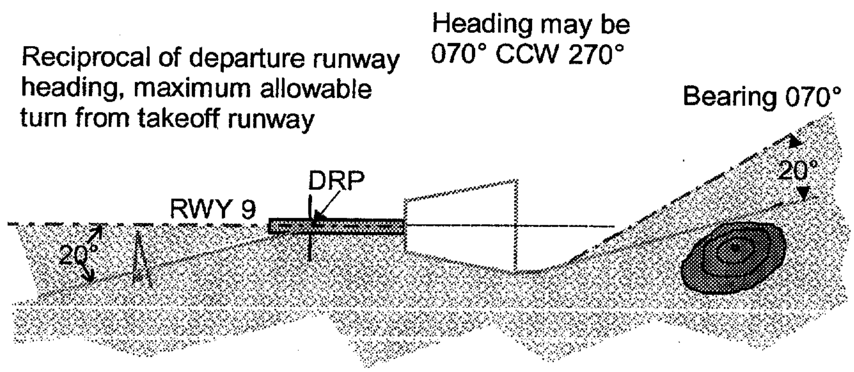
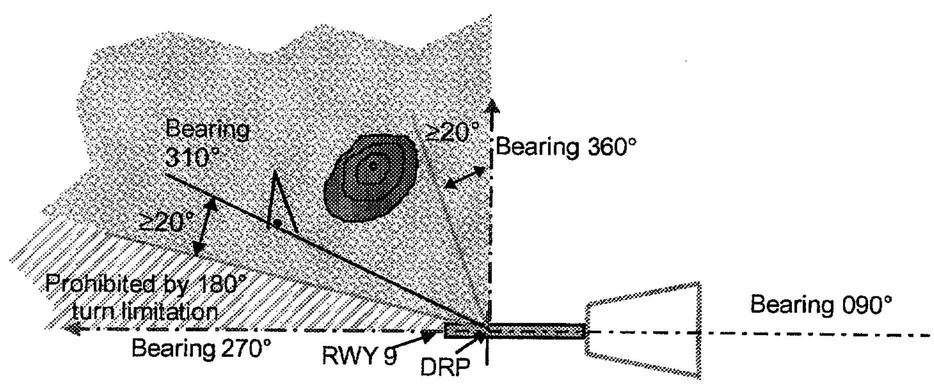


Figure 2-7B shows a sector of 360° clockwise, 270° could be assigned; however, the maximum turn to the right is a heading not in excess of the reciprocal of the takeoff runway heading.

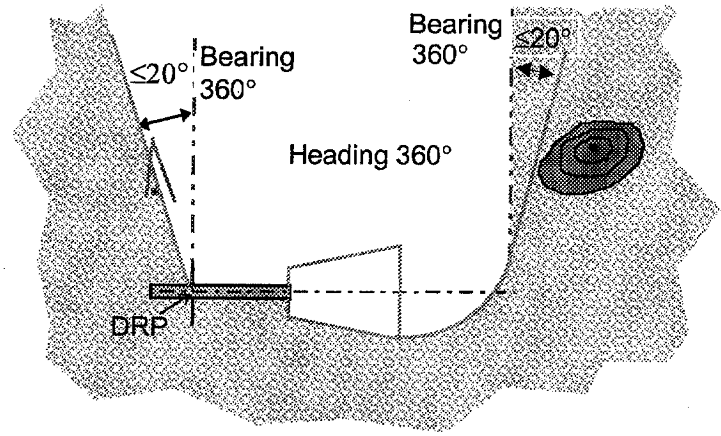
Figure 2-7B. Maximum Heading Limitation



Heading may be 360° CW to 270°

2.2.3 b. **Assign a single heading for a sector** which has parallel boundaries. The heading must parallel the boundaries. Figure 2-8 shows heading 360° as the only heading allowable.

Figure 2-8. Parallel Boundaries



2.2.3 c. **Do not establish a sector** if the boundaries converge. Example: In figure 2-8, if the bearing from the DRP had been 001° or greater or the outer bearing 359° or less, the sector could not be established.

2.3 DVA EVALUATION (ASR Required).

A DVA area based on diverse departure criteria may be established at the request of the AT manager and developed for any airport within the radar facility's area of jurisdiction and radar coverage. When established, reduced separation from obstacles is provided by application of the 40:1 OCS which will be used to radar vector departing IFR aircraft below the MVA/MIA. DVA's should not be developed that require climb gradients greater than 200 ft/NM unless there is no other suitable means to avoid obstacles except in situations where high volumes of high performance aircraft routinely make accelerated climbs.

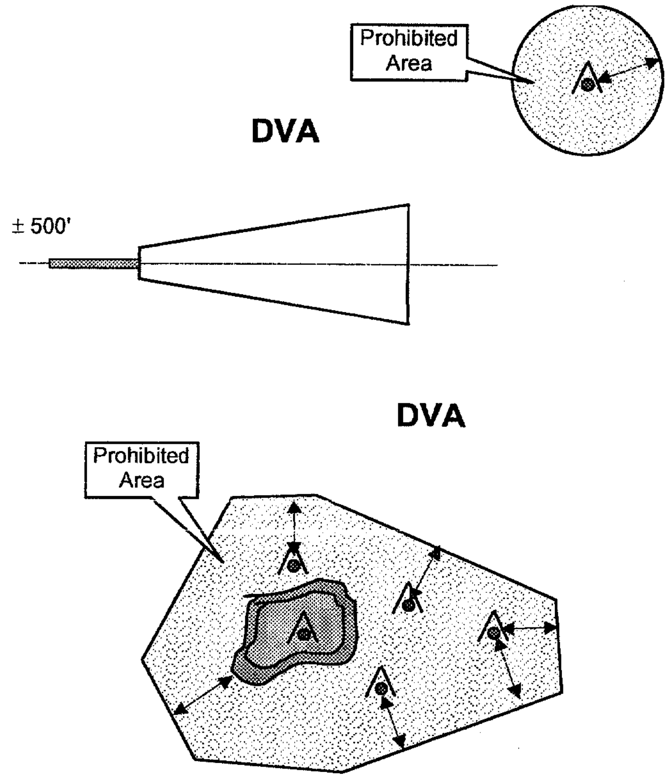
2.3.1 ICA.

See chapter 1, paragraph 1.6.

2.3.2 DVA "A" and "B" Areas.

Where obstacles penetrate the 40:1 OCS, construct a prohibited sector containing the obstruction(s) so it may be avoided by appropriate radar separation standards. Identify prohibited sectors with boundary lines 3/5 NM, as appropriate, from the penetrating obstacle(s). See figure 2-9.

Figure 2-9. Typical DVA Areas

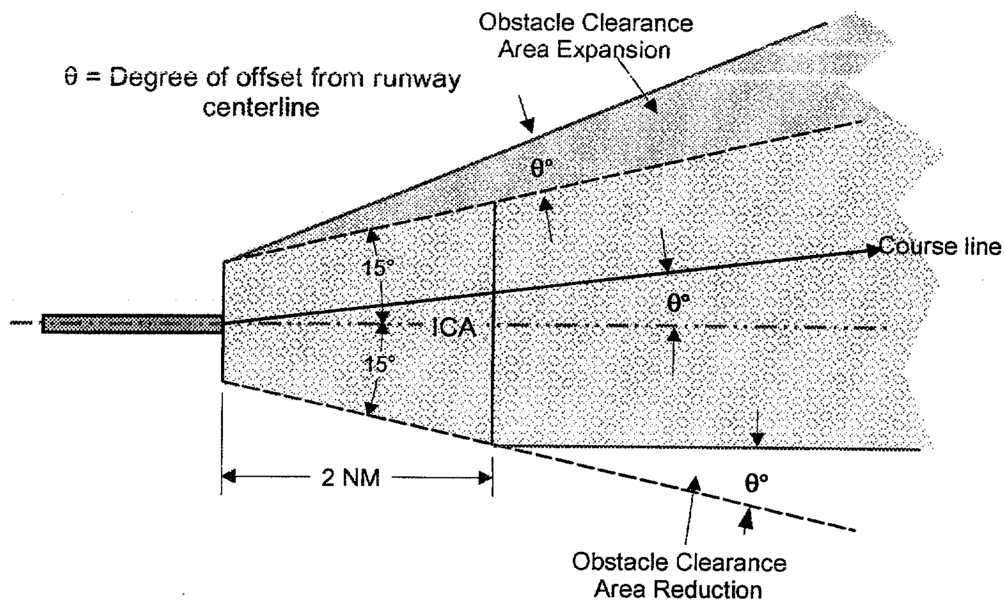


CHAPTER 3. DEPARTURE ROUTES

3.0 STRAIGHT ROUTE DEPARTURE SEGMENTS.

Straight departures are aligned within 15° of the runway centerline. The initial climb area (ICA) is aligned along the runway centerline for at least 2 NM (see paragraph 1.6). If a turn at the departure end of runway (DER) is desired, expand the obstacle clearance area in the direction of the turn an amount equal to the departure course degree of offset from runway centerline (see figure 3-1). Reduce the obstacle clearance area following the ICA on the side opposite the turn an amount equal to the expansion on the opposite side.

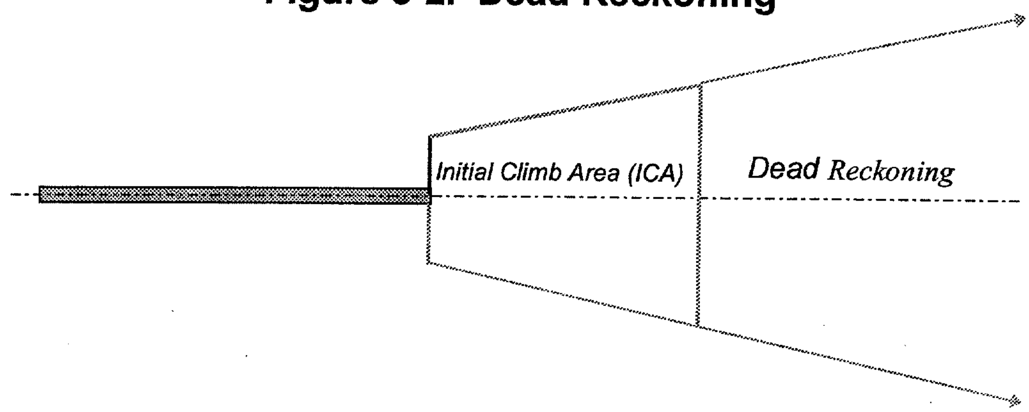
Figure 3-1. Turn ≤15° at DER



3.1 DEAD RECKONING (DR) DEPARTURE.

The boundary lines of the departure obstacle clearance surface (OCS) splay outward 15° relative to the departure course from the end of the ICA (see figures 3-1 and 3-2). Limit the DR segment to a maximum distance of 10 NM from DER.

Figure 3-2. Dead Reckoning



3.2 POSITIVE COURSE GUIDANCE (PCG) DEPARTURE, 15° OR LESS.

Calculating Obstruction Area Half Widths. Apply the values from table 3-1 to the following formulae to calculate the obstruction primary area half-width (1/2 W_P), and the width of the secondary area (W_S).

$$\tfrac{1}{2}W_p = k \times D + A$$
$$W_S = f_S \times D + A$$

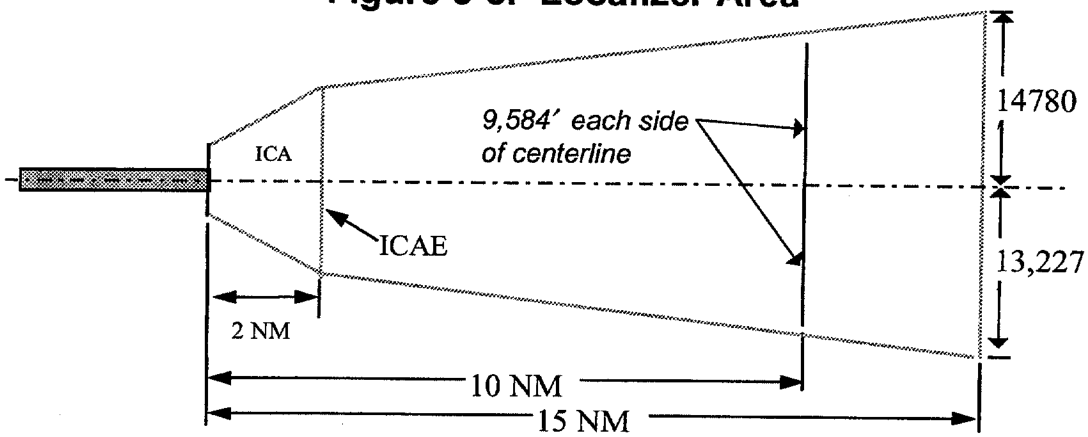
Table 3-1

½ Width	k	f_s	D	A
Dep DR	0.267949	none	Distance (ft) from DER	500′
Localizer	0.139562	none	Distance (ft) from ICAE	3756.18′
NDB	0.0333	0.0666	Distance (NM) from facility	1.25 NM
VOR / TACAN	0.059	0.099	Distance (NM) from facility	1 NM

3.3 LOCALIZER GUIDANCE.

The obstruction evaluation area (OEA) begins at the initial climb area end-line (ICAE). The maximum length of the segment is 15 NM from DER. Evaluate for standard climb gradient (SCG) in accordance with paragraph 1.4.1. If necessary, calculate the required minimum climb gradient using the formula in paragraph 1.4.2 where D is the shortest distance to the initial climb area baseline (ICAB) (see figure 3-3).

Figure 3-3. Localizer Area



3.3.1 **NDB Guidance.** Evaluate for SCG in accordance with paragraph 1.4.1. If necessary, calculate the required minimum climb gradient using the formula in paragraph 1.4.2. Figures 3-5, 3-6, and 3-7 illustrate possible facility area configurations.

3.3.2 **VOR/TACAN Guidance.** Evaluate for SCG in accordance with paragraph 1.4.1. If necessary, calculate the required minimum climb gradient using the formula in paragraph 1.4.2. Figures 3-4, 3-5, and 3-6 illustrate possible facility area configurations.

Figure 3-4. Facility Area and DR Area Relationship

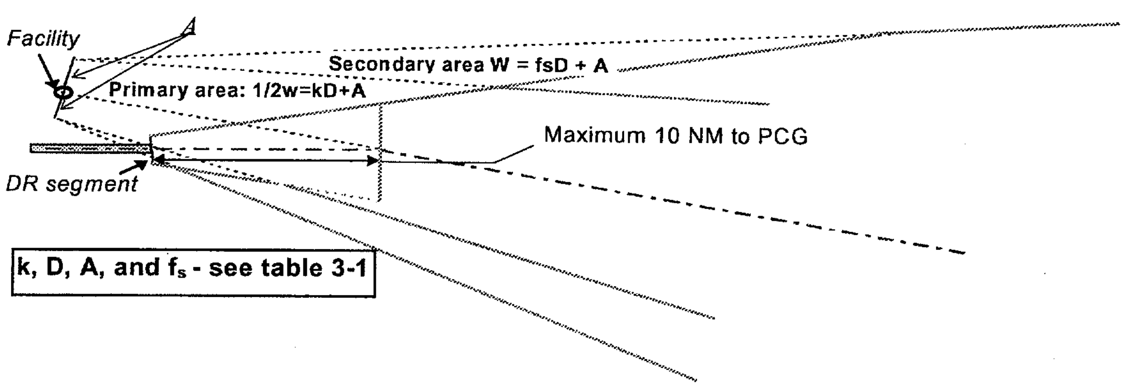
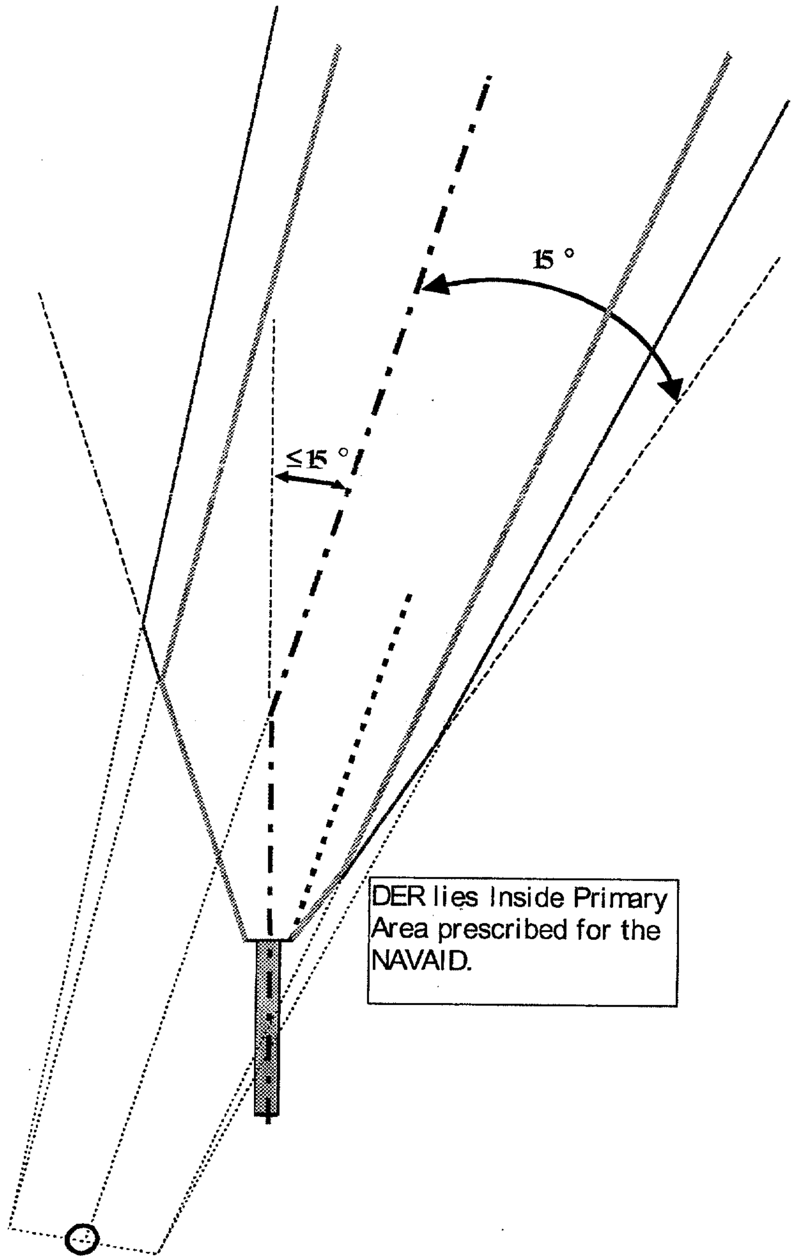


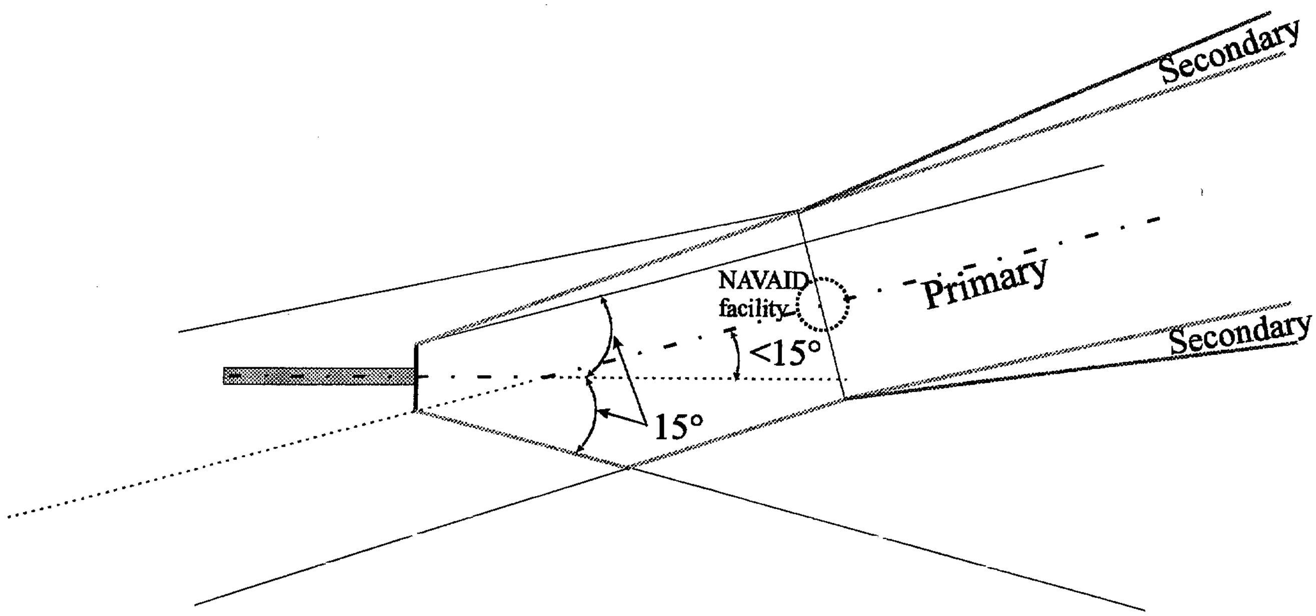
Figure 3-5. DER within Primary Area Facility



3.3.3 **Secondary Area Obstructions.** Secondary areas may be constructed and employed where PCG is provided.

3.4 **RESERVED.**

Figure 3-6. Facility Area Relationship



3.5 **TURNING SEGMENT CONSTRUCTION.**

3.5.1 **General.** Construct turning segments when the course change is more than 15°. Establish an ICA. For outer boundary radius use table 3-2 and apply paragraphs 3.5.1a through 3.5.1d, as appropriate. Use next higher airspeed in table 3-2 if specific speed is not given.

3.5.1 a. **For turns below 10,000 feet** mean sea level (MSL), use 250 KIAS unless a speed restriction other than 250 KIAS is noted on the procedure for that turn. Use 200 KIAS for a minimum speed for Category C and 230 KIAS for Category D aircraft.

3.5.1 b. **For turns at 10,000 feet and above,** use 310 KIAS unless a speed restriction not less than 250 KIAS above 10,000 through 15,000 feet is noted on the procedure for that turn. Above 15,000 feet, speed reduction below 310 KIAS is not permitted.

3.5.1 c. **When speeds greater than** 250 KIAS are authorized below 10,000 feet MSL, and speeds greater than 310 KIAS are authorized at or above 10,000 feet MSL, use the appropriate speed in table 3-2.

3.5.1 d. **Use the following standard** Note to publish a speed restriction: "Do NOT exceed (speed) until CHUCK (fix)."

Table 3-2

	Primary Area Outer Boundary radius (R1)			
Aircraft Speeds	**90**	**120**	**150**	**175**
Turn radii:				
Below 10,000′ MSL	0.9	1.4	1.9	2.4
10,000′ MSL and above	1.4	2.0	2.7	3.3
Aircraft Speeds	**180**	**210**	**240**	**250**
Turn radii:				
Below 10,000′ MSL	2.5	3.2	3.9	4.2
10,000′ MSL and above	3.4	4.3	5.2	5.5
Aircraft speeds	**270**	**300**	**310**	**350**
Turn radii:				
Below 10,000′ MSL	4.7	5.6	6.0	7.3
10,000′ MSL and above	6.2	7.3	7.7	9.3

(Speeds include 60-knot omni winds below 10,000′ MSL; 90-knot omni winds at 10,000′ and above; bank angle 23°.)

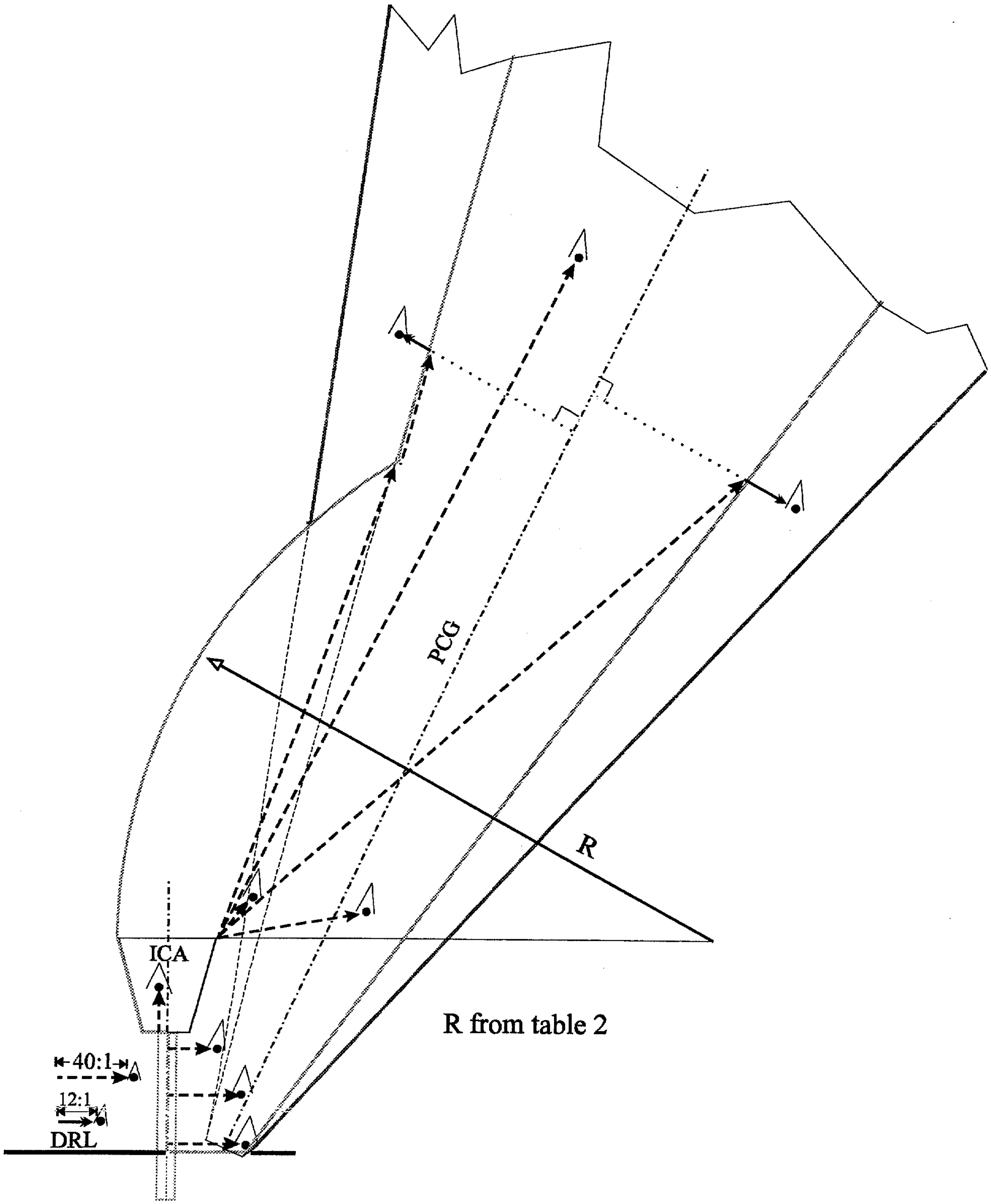
3.6 RESERVED.

3.7 TURN TO PCG.

3.7.1 **Extend the ICA boundaries** as necessary to intersect the boundaries appropriate to the PCG provided. Where the ICA outer boundary will not intersect the PCG boundary, construct an outer boundary radius from the outer edge of the ICA to intersect the PCG boundary. For the radius length, use table 3-2 or the width of the end of ICA, whichever is longer (see figure 3-7).

3.7.2 **Specify a course, not aligned with the runway centerline,** to intersect a PCG course. The amount of turn is not restricted.

Figure 3-7. ICA Joining PCG Area



3.8 MULTIPLE TURNS.

Use table 3-1 to establish dimensions of basic trapezoids.

3.8.1 **Climb to Altitude and Turn; Turns less than 90°.** See figure 3-8. Construct a line from departure reference point (DRP) to edge of obstacle area at the fix denoting the second turn point. Extend splay of ICA to line A,B, (perpendicular to runway centerline extended), where altitude is reached for the turn. Measure out runway centerline extended using SCG.

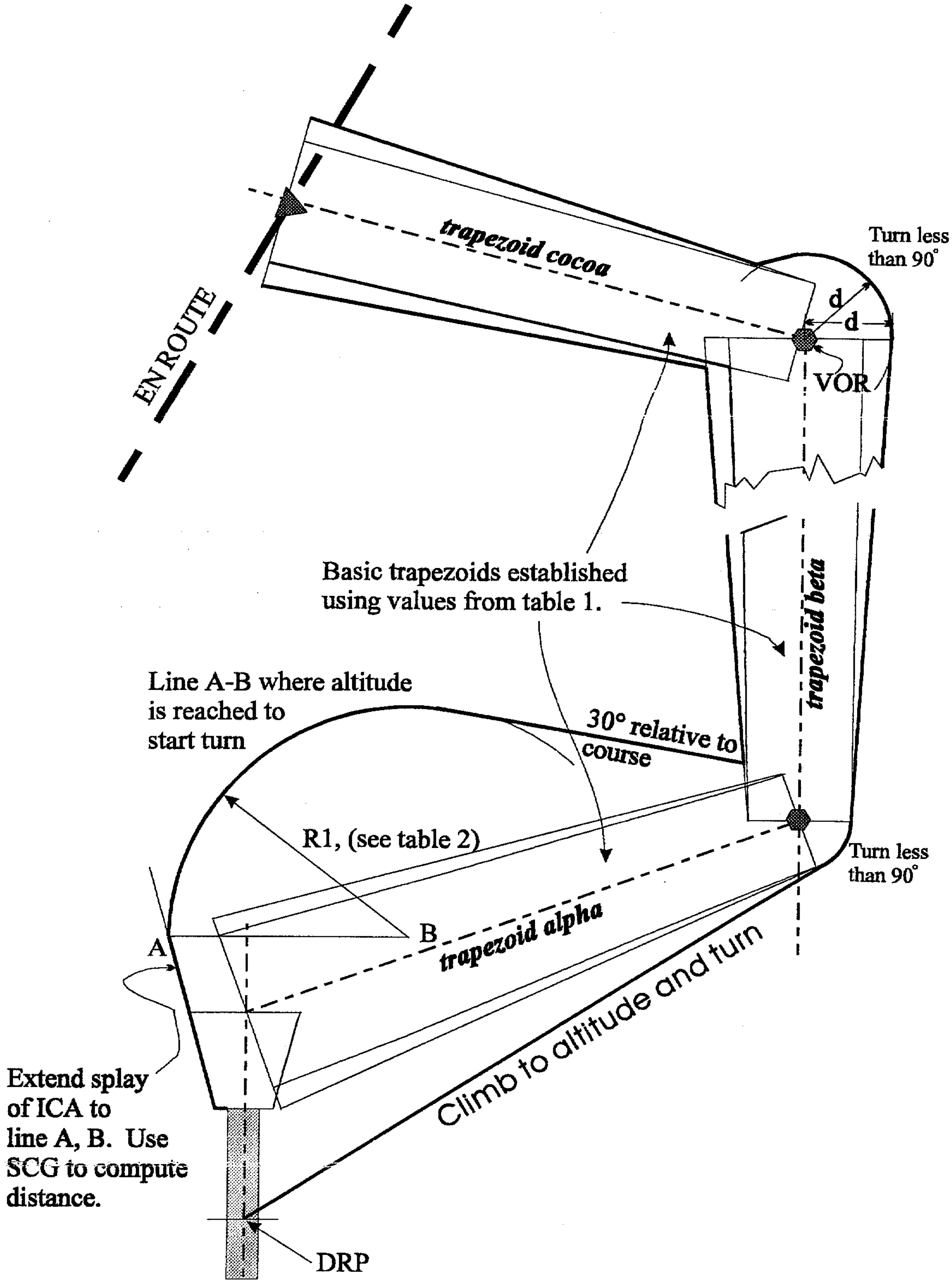
3.8.1 a. **Align the centerline** of trapezoid alpha, through point C (end of ICA on runway centerline extended).

3.8.1 b. **Construct an arc from point A** using radius R1 (table 3-2) centered on point B. Construct a tangent from the arc to the boundary of the secondary area of the next segment, (trapezoid beta), 30° relative to trapezoid alpha centerline.

3.8.1 c. **Construct trapezoid beta.** Extend the outer boundary area, radius "d", to join trapezoid cocoa. Inside boundaries join at the primary and secondary intersections.

3.8.1 d. **Construct trapezoid cocoa** and its associated segment, if necessary, to join en route structure.

Figure 3-8. Climb to an Altitude and Turn Direct to Fix with Multiple Turns.



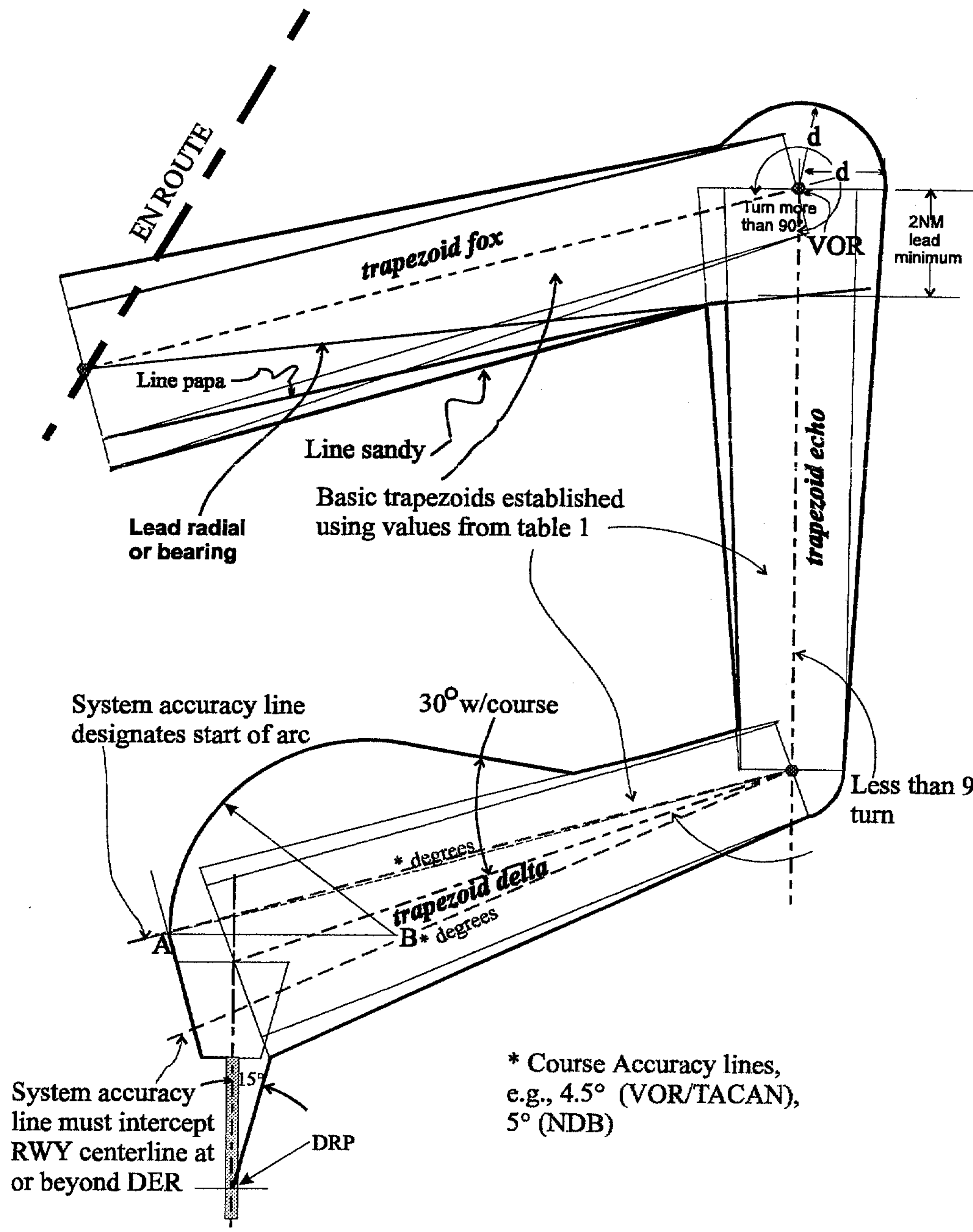
3.8.2 **Climb to Intercept a Course.** See figure 3-9. Construct a 15° splay relative to runway centerline from the departure reference point (DRP) to the secondary boundary of trapezoid delta (inside of turn) area. System accuracy line of delta must intercept runway centerline at or beyond DER.

3.8.2 a. **Extend the splay of ICA to line A, B.** System accuracy line of trapezoid delta (outside of turn) intercepts the ICA splay at point A.

3.8.2 b. **Construct an arc from point A** using radius R1 (table 3-2) centered on point B. Construct a tangent from the arc to the boundary of next segment (trapezoid echo) 30° relative to trapezoid delta centerline.

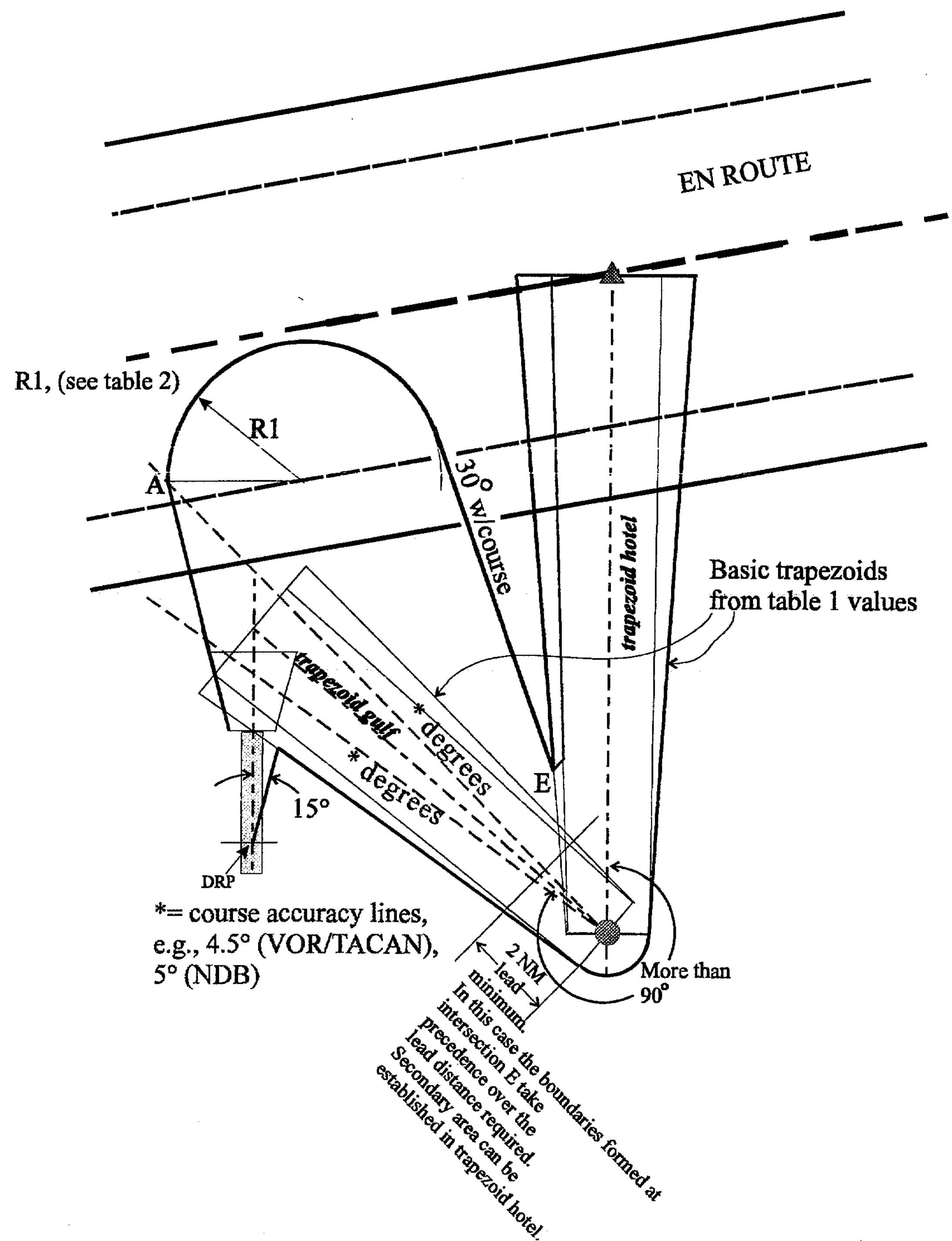
3.8.2 c. **Construct trapezoids echo and fox** as necessary. Provide a 2-NM lead area when turns are more than 90°, prior to the "VOR" turning into trapezoid fox. Specify a 2-mile lead when possible with a radial, bearing, or DME. When unable to identify the lead point, construct and provide a 2-mile lead area for evaluation of obstacles. Outside protection arc must be as large as the end of the trapezoid, i.e., "d" at fix jiffy. In the segment containing trapezoid fox, note primary "line papa" and secondary "line sandy" originate from the 2-mile lead of trapezoid echo.

Figure 3-9. Climb RWY Heading to Intercept a Course With Multiple Turns.



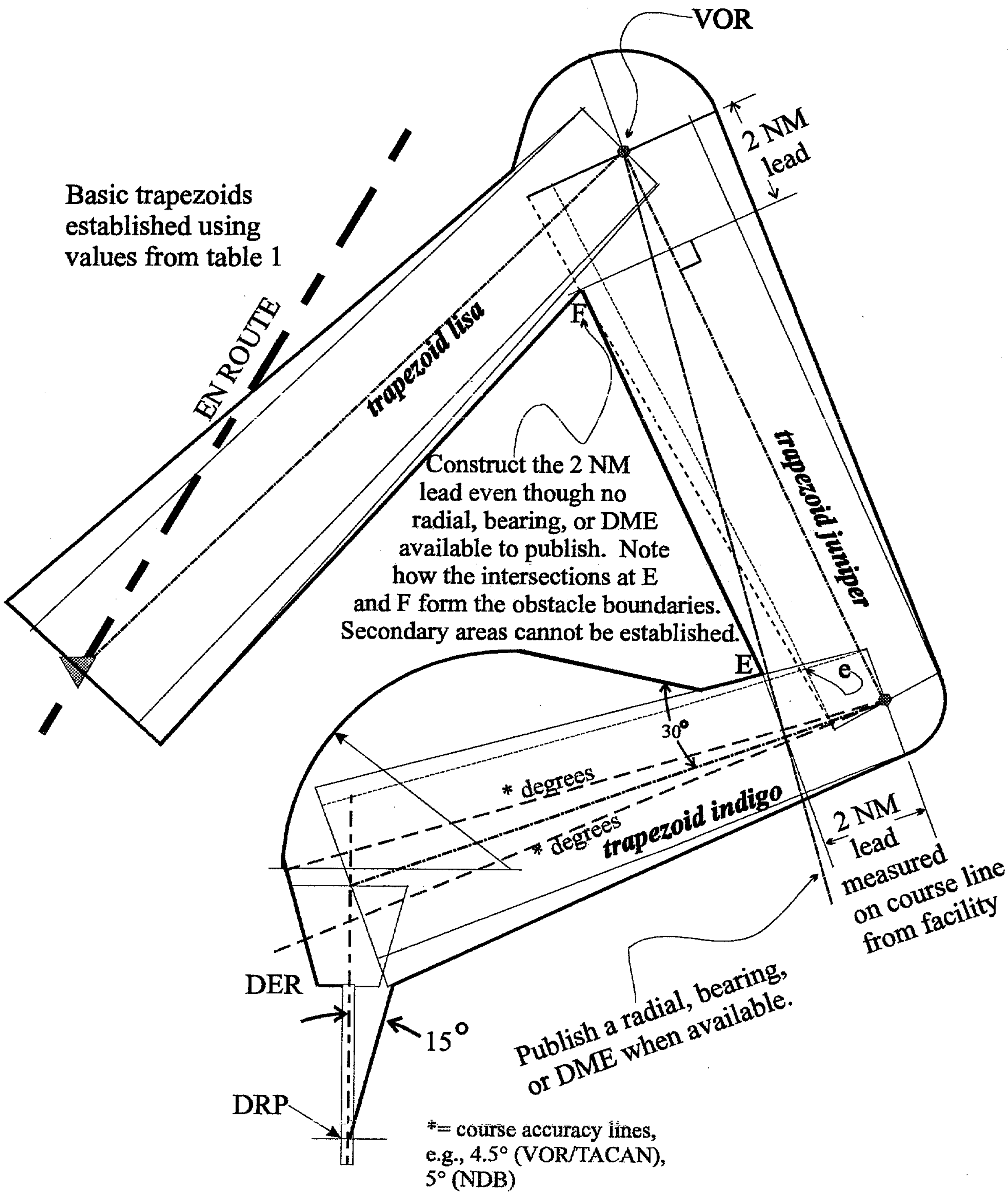
3.8.3 **Figure 3-10 illustrates multiple turns more than 90°.** Initial course intercepts positive course of trapezoid gulf after takeoff from DER. The obstacle area radius is constructed from point A with a tangent 30° relative to the course in trapezoid gulf. The area formed around the intersection of E with trapezoid hotel takes precedence over the 2-NM lead requirement. Primary and secondary areas can be established on the inside of the turn in trapezoid hotel because the 2-mile lead does not cut off any of the primary area.

Figure 3-10. Climb to Intercept Course.



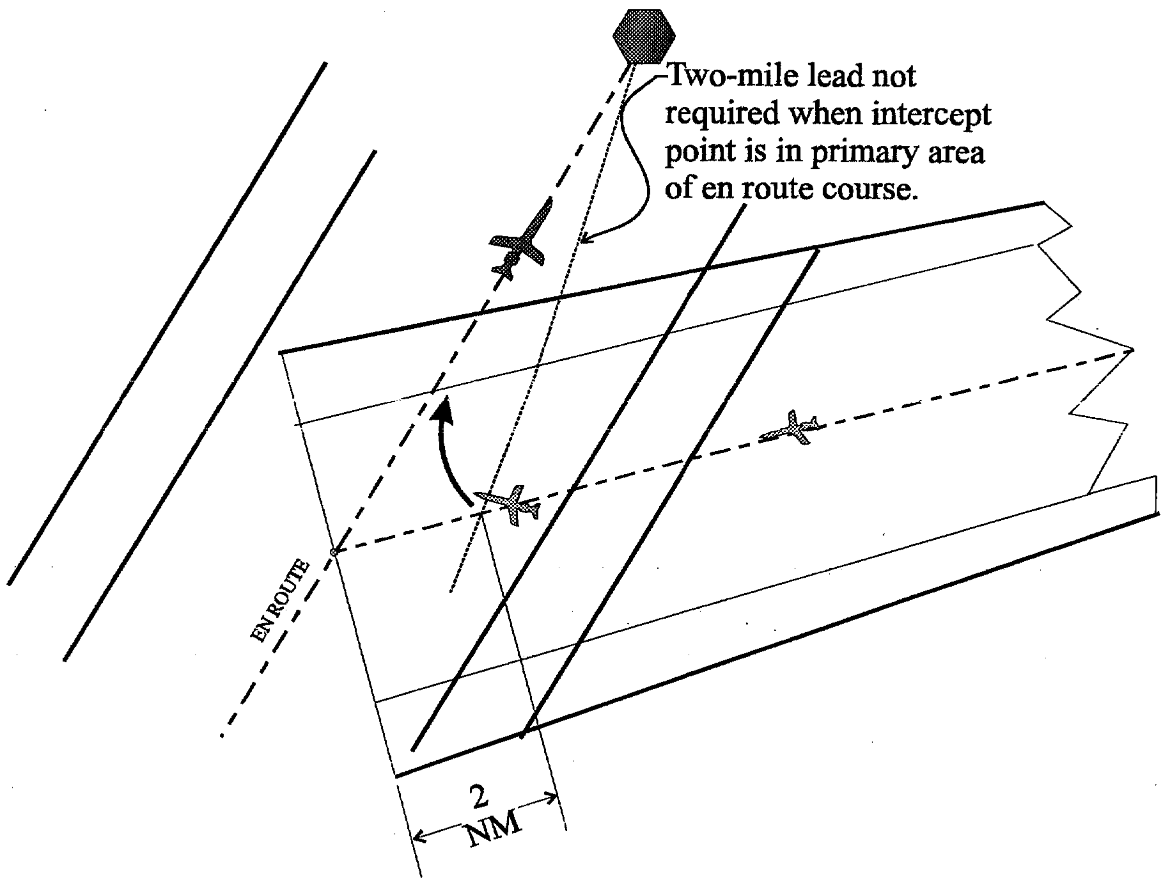
3.8.4 **Figure 3-11 illustrates multiple turns more than 90°.** Publish either a radial, bearing, or a DME when available. Construct a 2-NM lead even though no radial, bearing, nor DME is available. This provides a lead area for the pilot's early turn. Note how the intersections at E and F form the boundaries of obstacle clearance areas. Point E is established abeam the 2-mile lead. The dark lines around point E form a primary area boundary. A secondary area cannot be established on the inside area of trapezoid juniper because the 2-mile lead forms the area that takes precedence over the normal primary and secondary areas at "e".

Figure 3-11. Multiple turns.



3.8.5 **Figure 3-12 illustrates the 2-mile lead** not required when lead point is within primary area of en route course.

Figure 3-12. Turn on to En Route Course.



3.8.6 **Evaluation of Multiple Turn Areas.** See figures 3-13 and 3-14.

3.8.6 **a. Measure 40:1 straight-line distance** from lines d-c-b of the ICA directly to the obstacles outside of the ICA associated with trapezoid alpha in figure 3-13 and trapezoid gulf in figure 3-14. Measure 40:1 from runway centerline to obstacles abeam the runway between the DRP and the DER. Points b and c are at the end of the ICA, a and d at corners of the ICA abeam the DER. In figure 3-13, no secondary areas exist in trapezoid alpha's segment, and in figure 3-14, no secondary evaluation is allowed for the far turn from DER because the beginning of PCG cannot be determined. However, on the inside turn area a secondary area evaluation could be allowed for trapezoid gulf's segment.

3.8.6 b. **Measure 40:1 to point E for obstacles** in trapezoids beta, figure 3-13, and hotel, figure 3-14, segments, respectively. Measure 12:1 into secondary area from edge of primary area perpendicular to the segment's course. Convert the secondary area obstacles to primary equivalent at edges of primary area. Measure 40:1 to the conversion points to assess appropriate obstacle clearance.

3.8.6 c. **Measure 40:1 to E, then 40:1 down the edge** of the primary area of trapezoid beta from E to F to obstacles in trapezoid cocoa's segment. From F measure 40:1 to obstacles in primary area of trapezoid cocoa, figure 3-13. Measure along edge of primary area to a point abeam the obstacles in secondary area. Measure 12:1 from edge of primary area to the obstacle in secondary area perpendicular to applicable course line. Perform secondary area obstacle evaluation.

3.8.6 d. **Climbing in a Holding Pattern.** When a climb in a holding pattern is used, no obstacle shall penetrate the holding pattern obstacle clearance surface. This surface begins at the end of the segment, F-G, figure 3-14, leading to the holding fix. Its elevation is that of the departure OEA at the holding fix. It rises 40:1 from the nearest point of the F-G line to the obstacle in the primary area. It also rises 40:1 to the edge of the primary area of the holding pattern abeam an obstacle in the secondary area of the holding pattern. In the secondary area, the surface rises 12:1 to the obstacle measuring the shortest distance between the obstacle and the edge of the primary area (see figure 3-14). The holding pattern altitude must have a level surface evaluation of 1,000 feet.

Figure 3-13. Climb to an Altitude and Turn Direct to Facility with Multiple Turns.

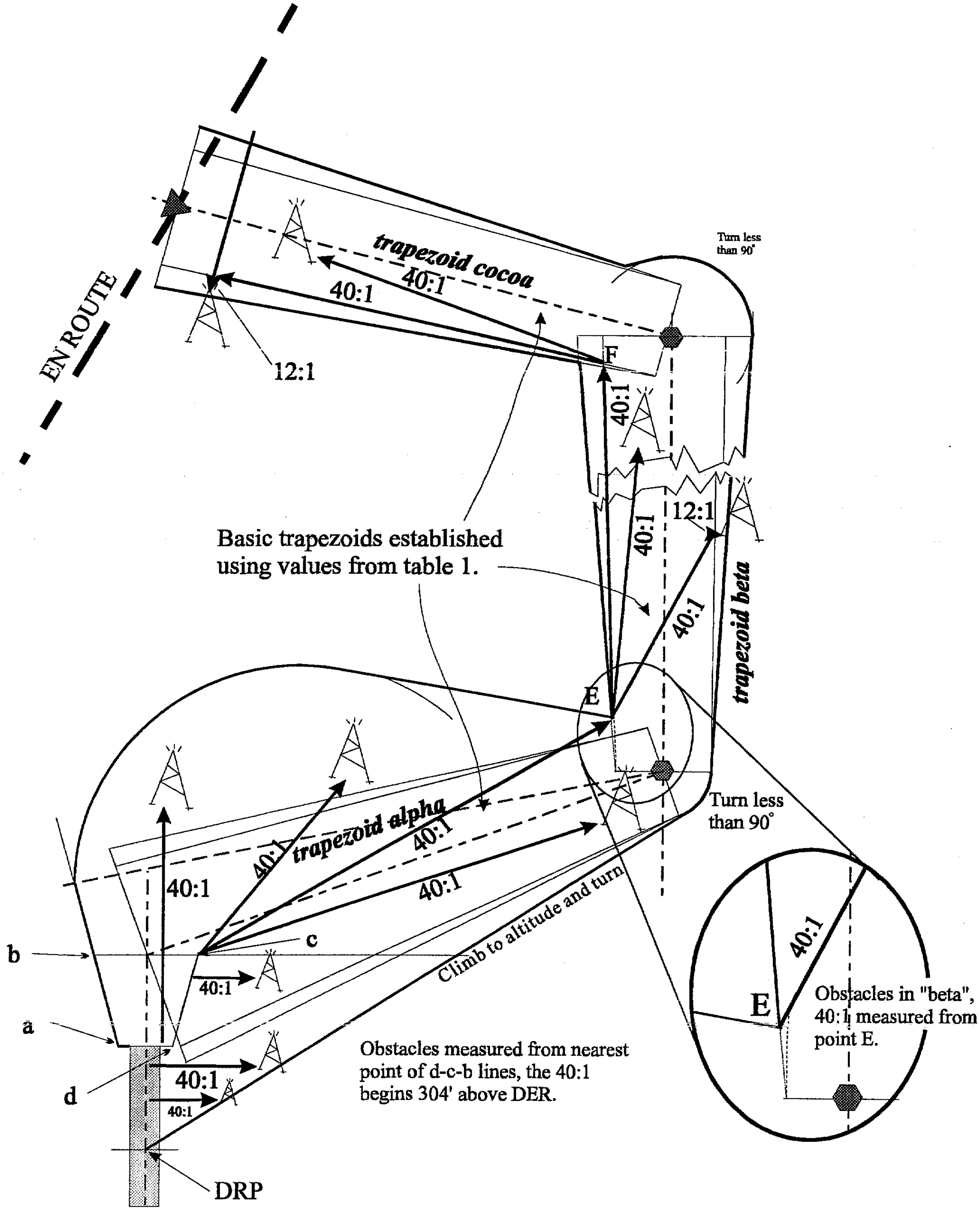
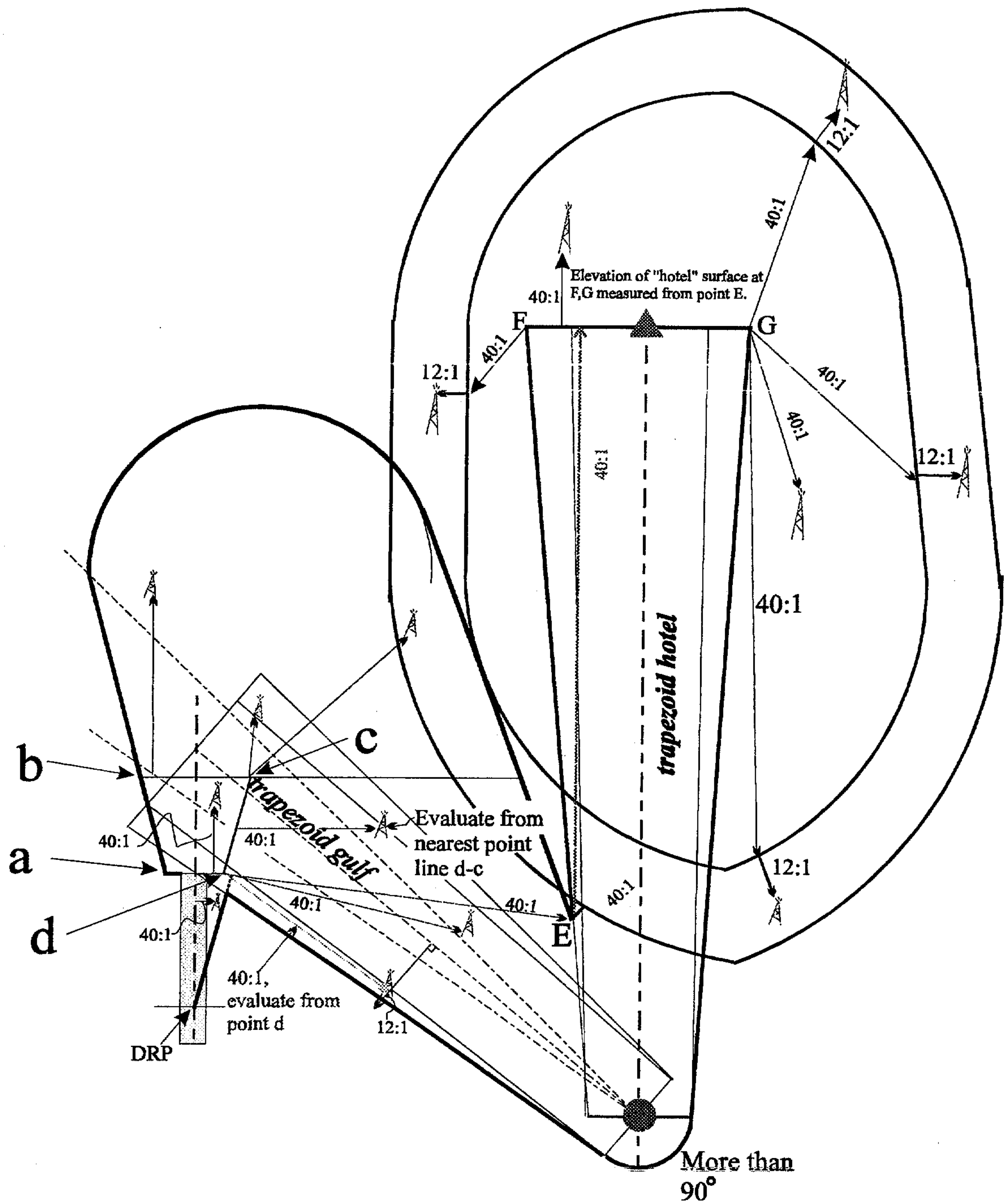


Figure 3-14. Climb in a Holding Pattern, Turns More Than 90 Degrees Evaluation.



CHAPTER 4. VISUAL CLIMB OVER AIRPORT (VCOA)

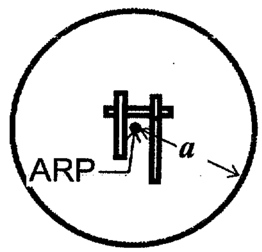
4.0 GENERAL.

VCOA is an alternative method for pilots to depart the airport where aircraft performance does not meet the specified climb gradient. Development of a VCOA is mandatory when obstacles more than 3 statute miles from the departure end of runway (DER) require a greater than 200 ft/NM climb gradient.

4.1 BASIC AREA.

Construct a visual climb area over the airport using the airport reference point (ARP) as the center of a circle (see figure 4-1). Use R1 in table 4-1 plus the distance ARP to the most distant runway end as the radius for the circle.

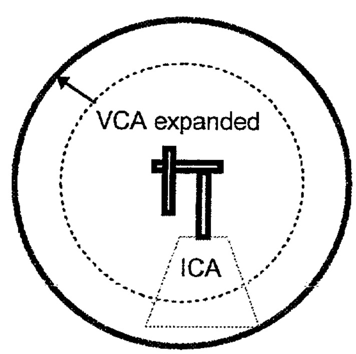
Figure 4-1. VCA



a=R1 (table 1-3) plus the Distance from ARP to most distant DER

Select 250 KIAS as the standard airspeed and apply the appropriate MSL altitude to determine the R1 value. Use other airspeeds in table 4-1, if specified on the procedure, using the appropriate radius for the selected airspeed. Altitude must equal or exceed field elevation. The VCA must encompass the area of the ICA from the departure runway(s). Expand the VCA radius if necessary to include the ICA (see figure 4-2).

Figure 4-2. VCA Expanded



The VCA must completely encompass the ICA.

Table 4-1. Radius Values

Altitudes MSL	2,000'	5,000'	10,000'
Speed KIAS			
90	2.0	2.0	2.0
120	2.0	2.0	2.0
180	2.0	2.0	2.5
210	2.1	2.5	3.2
250	2.8	3.4	4.2
310	4.2	4.9	6.0
350	5.2	6.0	7.3

(Table 4-1 speeds include 30-knot tail winds up to 2,000' MSL, 45-knot tail winds up to 5,000' MSL, and 60-knot tail winds at 10,000′ MSL; bank angle: 23°.)

4.2 VCOA EVALUATION.

4.2.1 Diverse VCOA.

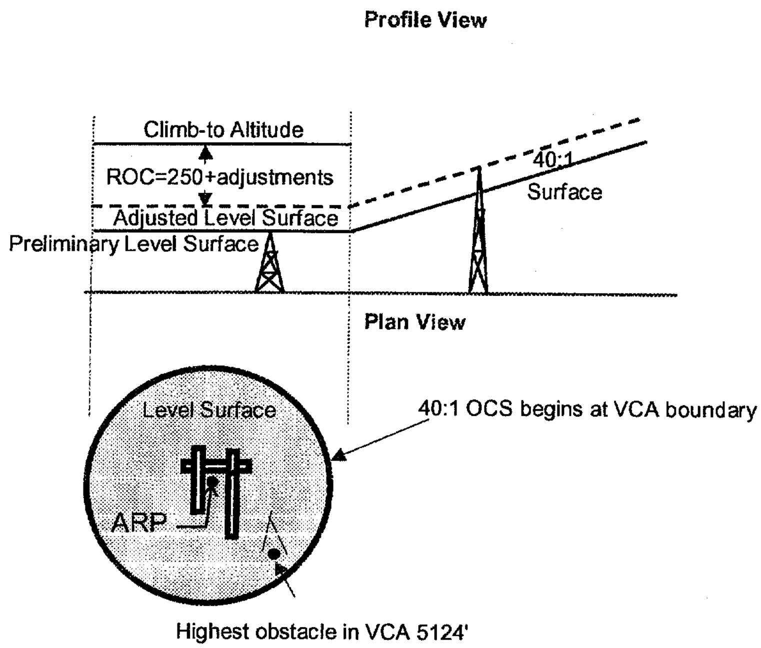
Identify the highest obstruction within the visual climb area (VCA). This is the preliminary height of the VCA level surface. Evaluate a 40:1 surface from the edge of the level surface. If the 40:1 surface is penetrated, raise the VCA level surface height by the amount of the greatest penetration (see figure 4-3). Determine the VCOA "climb-to" altitude using the following formula:

$$\text{climb to altitude} = \text{level surface MSL height} + 250' \text{ ROC} + \text{adjustments (vol. 1, para 323a)}$$

$$\text{Example: } 5124 + 250 + 0 = 5374 \text{ rounds to } 5400'$$

$$\text{Where OCS height} = 5124$$
$$\text{adjustments} = 0$$

Figure 4-3. Diverse VCOA Evaluation



4.2.2 **Departure Routes.**

Where VCOA Diverse Departure is not feasible, construct a VCOA departure route.

4.2.2 a. **Construct** the VCA per paragraph 4.1.

4.2.2 b. **Determine** the preliminary level surface height as in paragraph 4.2.1.

4.2.2 c. **Locate**, within the VCA, the beginning point of the route.

4.2.2 d. **Construct** the departure route using criteria for the navigation system desired. The 40:1 surface rise begins along a line perpendicular to the route course and tangent to the VCA boundary (see figure 4-4).

4.2.2 e. **OCS Evaluation.** Where obstacles penetrate the route 40:1 OCS:

4.2.2 e. **(1)** Raise the VCA level surface the amount of penetration. Determine the climb-to altitude using the formula below, **or...**

$$\text{climb to altitude} = \text{level surface MSL height} + 250'\ \text{ROC} + \text{adjustments (vol. 1, para 323a)}$$

$$\text{Example: } 5124 + 250 + 0 = 5374 \text{ rounds to } 5400'$$

$$\text{Where OCS height} = 5124$$
$$\text{adjustment} = 0$$

4.2.2 **e.** **(2)** Determine a climb gradient that will clear the obstacle using the formula:

$$CG = \frac{a - b}{0.76 \times d}$$

where a = obstacle MSL altitude
b = VCA climb - to altitude
d = distance (NM) from 40 : 1 origin to obstacle

$$\text{Example: } CG = \frac{3379 - 2100}{0.76 \times 5.34} = 315.15 \text{ ft/NM}$$

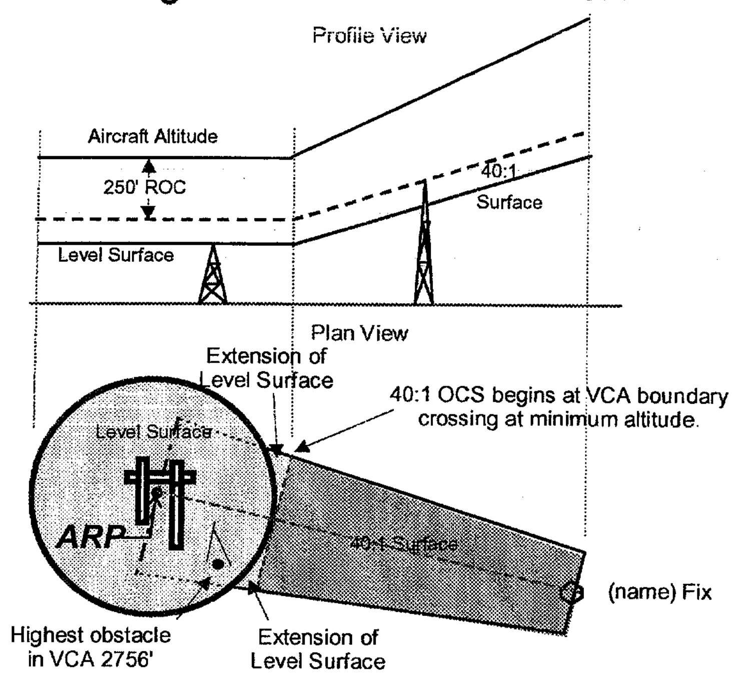
Calculate altitude (alt) that the CG may be discontinued:

$$alt = b + (d \times CG)$$

Example:

$$alt = 2100 + (5.34 \times 316) = 3787.44 \text{ round up to } 3800'$$

Figure 4-4. Route Out of VCA

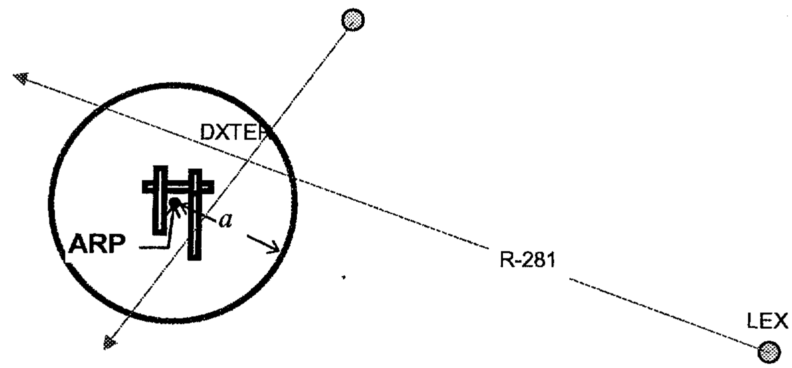


Climb to altitude	2800'
	+100
	2900
Airport	-2315'
Raw ceiling value	585'
Minimum Ceiling	600'

4.2.3 **Published Annotations.**

The procedure must include instructions specifying an altitude to cross a fix/location over the airport, followed by routing and altitude instructions to the en route system. Example: "Climb in visual conditions to cross Wiley Post airport westbound at or above 6,000′, then climb to FL180 via AMA R-098 to AMA VORTAC", "Climb in visual conditions to cross DXTER eastbound at 5,000′, then via LEX R-281 to LEX." (see figure 4-5).

Figure 4-5. VCOA Departure Route



4.3 CEILING AND VISIBILITY.

Publish a ceiling that is the 100-foot increment above the "climb-to" altitude over the VCA. Obstacles inside the VCA are subject to see and avoid maneuvers. Obstacles outside the VCA may be avoided by publishing a ceiling above an altitude that must be attained inside the VCA over a specified fix or identifiable point. From this altitude, a 40:1 OCS from the VCA boundary clears all obstacles outside the VCA omni-directionally, or along a route of flight (see figures 4-3, 4-4). Determine the published visibility from table 4-2.

Table 4-2. Visibility

Altitudes MSL	2,000'	5,000'	10,000'
Speed KIAS			
90	1	1	1
120	1	1	1 1/4
180	1 1/2	2	2 1/2
210	2	2 1/2	2 3/4
250	2 1/2	3	3
310	3	3	3
350	3	3	3

FAA ORDER **8260.3B**

Army
Navy
Coast Guard
Air Force

TM 95-226
OPNAV Inst. 3722.16C
CG 318
AFMAN 11-226(I)

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